INCH-POUND

MIL-R-28750C 16 February 1993 SUPERSEDING MIL-R-28750B 2 February 1984

#### MILITARY SPECIFICATION

### RELAYS, SOLID STATE, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

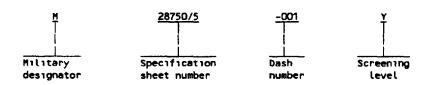
### 1. SCOPE

- 1.1 <u>Scope</u> This specification covers the general requirements for hermetically sealed or encapsulated solid state relays (SSR)(see 6.1), incorporating semiconductor, microelectronic, and passive circuit devices
  - 1.2 Solid state relay classification. (Shall appear on individual specification sheets.)

<u>Class I (discrete) construction</u>. SSR utilizing this type of construction, employs only discrete type components, which can be nonhermetically sealed. The completed SSR is hermetically sealed.

<u>Class II (hybrid) construction</u>: SSR utilizing this type of construction, employs chip (die) and wire bond construction. The completed SSR is hermetically sealed.

1.3 <u>Military Part or Identifying Number (PIN)</u>. The term Part or Identifying Number (PIN) is equivalent to the term part number which was previously used in this specification. The military PIN shall consist of the letter "M", the basic number of the specification sheet, an assigned dash number (see 3.1), and a screening level. The screening level indicates the level of quality and reliability. This specification currently provides only one level (see 3.7 and 6.8)



Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Defense Electronics Supply Center, ATTN: EMM, Dayton, OH, 45444-5270 using the self addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter

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### MIL-R-287500

### 2. APPLICABLE DOCUMENTS

### 2.1 Government documents.

2.1.1 <u>Specifications and standards</u>. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2)

### **SPECIFICATIONS**

#### FEDERAL

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ZZ-R-765 - Rubber, Silicone.
PPP-B-601 - Boxes, Wood, Cleated Plywood.
PPP-B-621 - Box, Wood, Nailed and Lock-corner.
PPP-B-636 - Box, Shipping, Fiberboard.
PPP-C-795 - Cushioning Material, Packaging (Flexible Closed Cell Plastic Film for Long Shipping Cycle Applications).
PPP-C-1752 - Cushioning Material, Packaging, Unicellular Polyethylene Foam, Flexible.
PPP-C-1797 - Cushioning Material, Resilient, Low Density, Unicellular, Polypropylene Foam.
PPP-C-1842 - Cushioning Material, Plastic, Open Cell (For Packaging Applications).
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### **HILITARY**

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MIL-I-10
            - Insulating Compound, Electrical, Ceramic, Class L.
MIL-H-14
            - Molding Compounds, Thermosetting.
MIL-C-17
            - Cable, Radio Frequency, Flexible and Semirigid, General Specification for
MIL-P-116
            - Preservation, Methods of
MIL-8-117
            - Bags, Steeves And Tubing.
MIL-P-997
            - Plastic Material, Laminated, Thermosetting, Electric Insulation, Sheets, Glass Cloth,
              Silicone Resin.
MIL-P-15037 - Plastic Sheet, Laminated, Thermosetting, Glass Cloth, Melamine Resin.
MIL-P-15047 - Plastic Material, Laminated Thermosetting Sheets, Nylon Fabric Base, Phenolic Resin
MIL-S-19500 - Semiconductor Devices, General Specification For.
MIL-I-23011 - Iron Nickel Alloys for Sealing to Glasses and Ceramics.
MIL-R-27777 - Relay, Telegraph, Passive, Solid-state General Specification For.
MIL-R-28776 - Relay, Hybrid, Established Reliability, General Specification For
MIL-M-38510 - Microcircuits, General Specification For.
MIL-H-38534 - Hybrid Microcircuits, General Specification For
MIL-G-45204 - Gold Plating, Electrode Deposited
MIL-N-46025 - Nickel Bar, Flat Wire (Ribbon) and Strip (For Electronic Use).
MIL-N-46026 - Nickel Rod and Wire (Round) (for Electronic Use).
MIL-R-55342 - Resistors, Fixed, Film, Chip, Established Reliability, General Specification For
MIL-R-55681 - Capacitors, Chip, Multiple Layer, Fixed, Unencapsulated, Ceramic Dielectric,
              Established Reliability, General Specification For
MIL-B-81705 - Barrier Material, Flexible, Electrostatic Free Heat Sealable
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(See supplement 1 for applicable specification sheets )

# STANDARDS

# FEDERAL

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FED-STD-H28 - Screw Thread Standards for Federal Services.
FED-STD-123 - Marking for Shipment (Civil Agencies)
FED-STD-209 - Clean Room and Work Station Requirements, Controlled Environment
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#### **HILITARY**

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MIL-STD-129
              - Marking for Shipment and Storage.
MIL-STD-202
               - Test Methods for Electronic and Electrical Component Parts.
MIL-STD-461
              - Electromagnetic Emission and Susceptibility Requirements for the Control of
                Electromagnetic Interference.
MIL-STD-462
              - Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-750
               - Test Methods for Semiconductor Devices.
MIL-STD-790
              - Product Assurance Program for Electronic and Fiber Optic Parts Specifications.
MIL-STD-883
              - Test Methods and Procedures for Microelectronics.
MIL-STD-889
              - Dissimilar Metals.
MIL-STD-977
              - Test Methods and Procedures for Microcircuit Line Certification.
MIL-STD-1189
              - Bar Code Symbology, Standard Department of Defense.
MIL-STD-1285
              - Marking of Electrical and Electronic Parts
MIL-STD-1346
              - Relay, Selection and Application.
              - Corrective Action and Disposition for Nonconforming Material.
MIL-STD-1520
MIL-STD-1686
             - Electrostatic Discharge Control Program for Protection of Electrical and
                Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated
                 Explosive Devices)(Metric).
              - Certification Requirements for Hybrid Microcircuit Facilities and Lines.
MIL-STD-2073-1 - DOD Material Procedures for Development & Application of Packaging Requirements.
MIL-STD-2073-2 - Packaging Requirement Codes.
MIL-STD-45662 - Calibration Systems Requirements.
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(Unless otherwise indicated, copies of federal and military specifications, and standards are available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

### AMERICAN NATIONAL STANDARDS INSTITUTE (AMSI)

ANSI Y32.2-1975 - Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation, Class Designation Letters).

(Application for copies should be addressed to the American National Standards Institute, 1420 Broadway, New York, New York 10018.)

# AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 170 - Standard Specification for Oxygen-Free Electrolytic Copper-Refinery Shapes

ASTM D 3953 - Standard Specification for Strapping, Flat Steel and Seals

ASTM F-15 - Specification for Iron-Nickel-Cobalt Sealing Alloy

ASTM F-30 - Standard Specification for Iron-Nickel Sealing Alloy.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103 )

### ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA-557 - Statistical Process Control Systems

(Application for copies should be addressed to the Electronic Industries Association, 2001 Eye Street, N W , Washington, DC 20006 )

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this document shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

### 3. REQUIREMENTS

- 3.1 <u>Specification sheets</u> The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of conflict between requirements of this specification and the specification sheet, the latter shall govern (see 6.2).
- 3.2 Qualification. Solid state relays furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.4 and 6.3).
  - 3.3 Quality.
  - 3.3.1 Product assurance program (PAP).
- 3.3 1.1 <u>Class I (discrete) construction</u>. The product assurance program for solid state relays manufactured using a Class I (discrete) construction furnished under this specification shall be established and maintained in accordance with the procedures and requirements specified in MIL-STD-790. The implementation of the PAP shall be within 12 months from the date of this specification
- 3 3 1.2 Class II (hybrid) construction The product assurance program for solid state relays manufactured using a Class II (hybrid) construction furnished under this specification shall be established and maintained in accordance with the procedures and requirements specified in MIL-STD-790 (NOTE: The qualifying activity for this specification may use certification of the manufacturing facility in accordance with MIL-H-38534 and MIL-STD-1772 as an alternate.) In addition the following requirements of 3.3 1.2 1 through 3.3.1.2.4.7.2 shall be met. The implementation of the PAP shall be within 12 months from the date of this specification.
- 3.3.1.2.1 <u>Design, processing, manufacturing equipment, and materials instructions</u> Solid state relay design, processing, manufacturing equipment and materials shall be documented in drawings, standards, specifications, or other appropriate media which shall cover the requirements and tolerances for all aspects of design and manufacturing including equipment test and prove—in, materials acquisition and handling, design verification testing and processing steps. As a minimum requirement, detailed documentation must exist for the following items and must be adequate to assure that quantitative controls are exercised, that tolerances or limits of control are sufficiently tight to assure a reproducible high quality product and that process and inspection records reflect the results actually achieved:
  - a Incoming materials control (substrates, packages, active and passive chips or elements, wire, water purification, etc.).
  - b Masking, photoresist, and mask registration
  - c Glassivation or passivation
  - d Metallization and film deposition
  - e Die, element, or substrate attachment
  - f Wirebonding
  - g Rework
  - h Sealing

- 3.3.1.2.2 Cleanliness and atmosphere control in work areas. The requirements for cleanliness and atmosphere control in each work area in which unsealed solid state relays, or parts thereof, are processed or assembled shall be documented. Air particle counts shall be in accordance with Federal Standard 209. The manufacturer shall establish action and absolute control limits (at which point work stops until corrective action is completed) based on historical data and criticalness of the process in each particular area. For foreign material identification and control, see internal visual inspection requirements of MIL-STD-883, method 2017.
- 3.3.1.2.3 Environment control The following are minimum environmental control requirements. The air particle counts for the classification indicated shall be as described in Federal Standard 209. All fabrication, assembly, and testing of Class III solid state relays prior to present visual shall be in an environment meeting class 100,000 particle count requirements, except soldering operations may be performed outside this environment and must be approved by the qualifying activity. Solid state relays awaiting present visual inspection, solid state relays accepted at present visual inspection and awaiting further processing, and noncontinuous production lots (Moncontinuous production shall occur when solid state relays are held by the manufacturer, with no additional assembly work performed, for more than 30 days.) accumulated after element attach and prior to present visual (including solid state relays delidded for rework or repair) shall be stored in a dry nitrogen environment. The present visual inspection and the preparation for sealing environment shall be in accordance with HIL-STD-883, methods 2017 and 2032.
- 3.3.1.2 4 Rework and repair provisions All rework and repair permitted on solid state relays shall be accomplished in accordance with procedures and safeguards in accordance with MIL-STD-790 and 3.3.1.2.1. This documentation shall reflect the processes, procedures, and materials to be used including verification or test data, and be approved by the qualifying activity of this specification. Each process or procedure shall be designated as rework or repair. This documentation shall indicate that a decision to rework is made solely by the manufacturer while a repair decision shall be made with the concurrence of the qualifying activity except for repairs permitted by this specification. When required, the Government shall participate in repair decisions (see MIL-STD-1520). A typical example of rework is the removal of a defective element and replacement with a new element. An example of repair is the use of an organically attached molytab to replace a previously alloy attached semiconductor element.

#### 3.3.1.2 4.1 General rework and repair provisions.

- a. All temperature excursions during any rework or repair shall not exceed the baselined rework or repair limitations. Time and temperature limits shall be specified.
- b Touch-up of package sealing surface plating on delidded packages is not permitted. Package sealing surface plating shall not be replated on delidded packages.
- c. The minimum distance between the glass to metal seals and the package sealing surface shall be at least 0 040 inch (1 02 mm) after final seal to prevent damage to lead seals by welding adjacent to them. (Applies to seam welding only.)
- d Any solid state relay which is reworked or repaired after present visual inspection shall be subjected to full screening or rescreening as applicable. If a solid state relay has not been subjected to a given required screen prior to rework or repair, then that solid state relay must be subjected to that screen after repair or rework. If a solid state relay has been subjected to a given screen prior to rework or repair, then rescreening applies as follows:
  - (1) Preseal visual inspection. Inspection for general damage (low magnification in accordance with MIL-STD-883, method 2017 and method 2032) which might have been caused by the rework or repair and perform a complete method 2017 or method 2032 inspection of the reworked or repaired element or area (e.g., replaced die, wirebonds, etc.)
  - (2) Stabilization bake, temperature cycle or shock, mechanical shock or constant acceleration, seal, and external visual. Rescreen all rework or repair solid state relays 100 percent
  - (3) Burn-in Solid state relays delidded to rework package seal failures do not require burn-in rescreen. Solid state relays which have had elements replaced or have been wirebonded or rewirebonded require 100 percent burn-in rescreen.

- e When flux is required for rework or repair, the specific flux and detailed procedures for its use and subsequent special cleaning operations shall be documented and approved in accordance with 3.3.1.2.1.
- f. Replacement elements shall not be bonded onto the chip element they are to replace.
- 3 3.1.2.4.2 <u>Element wire rebonding</u>. Wire rebonding of elements other than substrates shall be permitted with the following limitations:
  - a No scratched, voided, or discontinuous paths or conductor patterns on an element shall be repaired by bridging with or addition of bonding wire or ribbon.
  - All rebonds shall be placed on at least 50 percent undisturbed metal (excluding probe marks that do not expose underlying oxide). No more than one rebond attempt at any design bond location shall be permitted. No rebonds shall touch an area of exposed oxide caused by lifted or blistered metal. A bond shall be defined as a wire to post or wire to pad bond. Bond—offs required to clear the bonder after an unsuccessful bond attempt need not be visible, shall not be cause for reject and shall not be counted as a rebond.
- 3 3 1.2.4.3 <u>Substrate wire rebonding or repair</u> Wire rebonding on substrates shall be permitted with the following limitations:
  - a. Scratched, open, or discontinuous substrate metallization paths or conductor pattern on a substrate, not caused by poor adhesion, may be repaired by bridging with or by addition of bonded conductors having current carrying capacity at least 3.5 times the maximum calculated operating load current for the conductor or 3.5 times the current capacity of the wire bond connection terminating on the damaged conductor path. The quantity of repairs shall be limited to one for each one-half square inch or fraction thereof of substrate area.
  - b No rebonds shall be made over intended bonding areas in which the top layer metallization has lifted, peeled, or has been damaged such that underlying metallization or substrate is exposed at the immediate bond site
  - 3 3 1.2 4.4 Compound bonding Compound bonding for rework or repair is permitted only as follows:
    - a A gold ball bond on a substrate wire, a gold ball or a crescent bond
    - b Only monometallic compound bonds are permitted (i.e., the original bond wire and that used for compound bonding must be the same material).
    - c The new bond must cover at least 75 percent of the original bond or wire.
    - d. The maximum number of compound bonds shall not exceed 10 percent of the total number of wires
    - e A corrective action system must be utilized in order to reduce the number of compound bonds
    - f All compound bonds shall be 100 percent nondestructive pull tested in accordance with MIL-STD-883, method 2023.
    - g. A compound bond shall not be used to connect two wires.
    - h All compound bonds shall meet the visual criteria in MIL-STD-883, methods 2017 and 2032.

- 3.3.1.2.4.5 <u>Element replacement</u>. Element replacement shall be permitted with the following limitations:
  - a. Any polymer attached element may be replaced two times at a given location on any solid state relay.
  - b. Any metallic attached element may be replaced one time at a given location.
  - c. Any metallic attach element onto a plated tab where the tab is attached to a substrate with a higher temperature metallic attach process, may be replaced two times
  - d Substrates may be removed and put into a new package one time.
- 3.3.1.2.4.6 <u>Seal rework</u>. It shall be permissible to perform seal rework without delidding on solid state relays using hybrid construction that fail fine leak testing one time, only if tracer gas is included during the original sealing operation and under all of the following conditions.
  - a. Fine leak testing, without pressurization (bomb), must be performed immediately after sealing prior to any other test.
  - b. Solid state relays shall be stored in a nitrogen environment for a maximum of 4 hours between initial seal and reseal without replacing the cover.
  - c. Solid state relays shall be submitted to a predetermined vacuum bake prior to reseal.
  - d. Only lid to package seals shall be resealed. Solder sealed packages may not be reworked in accordance with this procedure.
  - NOTE: The above leak testing shall not be used as a substitute for the fine leak testing required in MIL-STD-883
- 3.3.1.2.4.7 <u>Delidding of solid state relays</u>. Hybrid construction solid state relays may be delidded and relidded for rework or repair provided the delid-relid procedures, controls, qualification plan, and resulting data are baselined and approved by the qualifying activity. Qualification of the delid-relid process shall be in accordance with subsection B-4 or B-5 of MIL-STD-1772. The number of delid-relid cycles allowed shall be in accordance with 3.3.1.2.4.7 1 or 3.3.1.2 4.7.2. Delid-relid history (i.e., traceability by lot number or serial numbers) shall be maintained by the solid state relay manufacturer and shall be made available for qualifying activity review upon request.
- 3.3.1.2.4.7.1 <u>Solder sealed solid state relays</u>. Solder sealed solid state relays may be delidded-relidded one time
- 3.3.1 2 4.7.2 <u>Welded solid state relays</u> Only seam sealed, overlapping pulse welded, or laser welded packages designed for delid-relid may be delidded-relidded. Solid state relays may be delidded-relidded two times. Additional (i.e., more than 2) delid-relid cycles shall be approved by the qualifying activity.

Qualifying of more than one delid-relid cycle shall be in accordance with subsection B-4 or B-5 of MIL-STD-1772, except the samples shall be delidded and relidded N + 1 times to qualify for "N" delid-relid cycles For example, the samples shall be delidded and relidded three times to qualify for two delid-relid cycles, four times to qualify for three delid-relid cycles, etc

- 3.3.2 <u>Statistical process control (SPC)</u>. The contractor shall implement and use statistical process control techniques in the manufacturing process for solid state relays covered by this specification. The SPC program shall be developed and maintained in accordance with EIA-557. The SPC program shall be documented and maintained as part of the overall reliability assurance program as specified in MIL-STD-790. The implementation of statistical process control shall be within 12 months from the date of this specification. Processes for application of SPC techniques may include but are not limited to:
  - a) Wirebonding.
  - b) Lid seal
  - c) Lead trim.
  - d) Final lead finishing (solder dip, etc.).
- 3 3.3 <u>Electrostatic discharge (ESD) control program</u>. As part of the PAP the manufacturer shall establish and maintain an ESD control program in accordance with MIL-STD-1686. Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification. This program shall be documented by an ESD control plan which must be under document control. As a minimum, this plan must address the identification of ESD sensitive (ESDS) sub-components and end items, facilities, training, design protection, handling procedures, marking, cleaning, preservation, packaging, and quality assurance. A model ESD control program is available from the qualifying activity and may be used as a guideline document.
- 3 4 Materials. Materials shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the solid state relays to meet the performance requirements of this specification. Materials used shall be self-extinguishing; and shall not support combustion, give off noxious gases in harmful quantities, give off gases in quantities sufficient to cause explosion of sealed enclosures, cause contamination to any part of the solid state relay, or form current carrying tracks when subjected to any of the tests specified herein. The selection of materials shall be submitted to the Government qualifying activity for approval. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.
- 3 4.1 <u>Plastic</u> Laminated plastic material shall conform to MIL-P-997, MIL-P-15037, or MIL-P-15047. Molded plastic material shall conform to MIL-M-14, except that cotton-filled or wood-flour-filled materials shall not be used
- 3 4.2 <u>Ceramic</u>. Ceramic insulating material shall conform to MIL-I-10, grade L422 or higher Ceramic used for external surfaces shall be glazed in accordance with MIL-I-10. Does not apply to substrate materials
- 3.4.3 <u>Metals</u> Metals shall be of a corrosion-resistant type or shall be plated or treated to resist corrosion, except that zinc plating, cadmium plating, or pure tin plating shall not be used. Zinc or cadmium plating shall not be used externally.
- 3 4.3.1 <u>Dissimilar metals</u> When dissimilar metals are used in intimate contact with each other, protection against electrolysis and corrosion shall be in accordance with MIL-STD-889
  - 3.4.4 <u>Rubber</u> Rubber shall conform to ZZ-R-765
- 3.5 <u>Circuit element requirements for Class II solid state relays</u> The requirements for circuit elements shall be in accordance with the appendix
- 3.6 <u>Design and construction</u> Solid state relays shall be of the design, construction, weight, and physical dimensions specified (see 3.1). Solid state relays shall be so designed to insure proper operation when mounted in any position. Solder shall not be used primarily for obtaining mechanical strength. All flux shall be removed after soldering.

- 3.6.1 <u>Threaded parts</u>. All threaded parts shall be in accordance with FED~STD-H28. Where practical, all threads shall be in conformity with the coarse-thread series. The fine-thread series may be used only for applications that show a definite advantage through their use. Where a special diameter-pitch combination is required, the thread shall be of American National Form and of any pitch between 16 and 36, which is used in the fine-thread series. Terminal threads shall be class 2A and class 2B for external and internal threads, respectively.
- 3 6.2 <u>Envelope (case, cover, or enclosure)</u>. Solid state relays with metal cases shall be provided with means to permit assured contact to ground. The enclosure shall not be electrically connected to any terminal, except one provided specifically for grounding or as specified (see 3.1).
- 3.6.3 Sealing process. Solid state relays shall be dried, degassed, and backfilled with gas having a dew point less than  $-65^{\circ}$ C (see 6.6), and shall be sealed to meet the requirements of 3.9. Adjunct sealant shall not be used.
  - 3.6.4 Mounting means. Hounting means shall be as specified (see 3.1).
- 3.6.4.1 <u>Socket</u>. Plug-in solid state relays shall be so designed that the weight of the solid state relay will be supported, and the stability of the mounting will be provided by means other than the terminals.
  - 3.6.5 Terminals (see 3.1). Terminals shall be as specified herein.
- 3.6 5.1 <u>Solder-lug terminals</u>. Solder-lug terminals shall be designed to accommodate two conductors, each rated to carry the maximum rated current of the contact or coil terminated
  - 3.6.5.2 <u>Wire leads</u>. Wire leads shall be as specified (see 3.1).
- 3 6 5.3 <u>Plug-in termination</u> Plug-in terminations shall conform to the arrangements or dimensions necessary for proper mating with the associated connectors or sockets as specified (see 3 1). The mounting arrangement of the solid state relay and its corresponding socket shall be so designed that the entire weight of the solid state relay will be suspended and the stability of its mounting will be provided by an auxiliary mounting means other than the electrical terminals of the socket (see 3.1). Solid state relays, during qualification, with plug-in terminals shall have electrical and environmental tests of section 4 performed with the appropriate or specified socket or connector assembled to the solid state relay. Plug-in terminals shall be gold plated in accordance with MIL-G-45204, type II, class I
- 3.6 5.4 <u>Screw</u>. Screw terminals shall be supplied with one nut, capable of engaging the screw by at least three full threads, two flat washers and one lock washer. The size of screw thread and length shall be as specified (see 3.1). At least three full threads of the screw shall protrude, be visible, with all hardware tightened in place.
- 3 6.6 <u>Circuit diagram</u>. The circuit diagram as specified (see 3 1), shall be a terminal view. Circuit symbols shall be in accordance with ANSI Y32.2. For solid state relays without an orientation tab, the circuit diagram as specified (see 3.1), shall be orientated so that when the solid state relay is held with the circuit diagram right side up as shown (see 3.1), and rotated away from the viewer about a horizontal axis through the diagram until the header terminals face the viewer, then each terminal shall be in the location shown on the circuit diagram.
- 3 6 7 <u>Temperature</u>. Unless otherwise specified (see 3.1), the solid state relay shall operate satisfactorily throughout the temperature range of -55°C to +125°C, and shall not be damaged when stored at a temperature in the range of -55°C to +125°C

### 3 6.8 Package

3 6 8 1 <u>Discrete construction</u> The outline dimensions of the package shall be as specified (see 3 1) Discrete construction solid state relays supplied under this specification shall be sealed in glass, metal or ceramic (or combination of these) packages. Adhesive or polymeric material shall not be used for package cover/lid attachment, seal or repair. Use of any other package material shall require prior approval from the qualifying authority.

3.6.8.2 <u>hybrid construction</u>. All hybrid construction solid state relays supplied to this specification shall be hermetically sealed in glass, metal, or ceramic (or combinations of these) packages. No adhesive or polymeric materials shall be used for package tid attach (or seal) or repair. Flux shall not be used in the final sealing process. The minimum distance between the glass to metal seals and the package sealing surface for seam welded packages after final seal shall be 0.040 inch (1.02 mm) minimum.

The internal water vapor content shall be determined in accordance with MIL-STD-883, method 1018 and shall not exceed 5,000 ppm at +100°C. Polymer impregnations or secondary seal (backfill, coating, or other uses of organic or polymeric materials to effect, improve, or repair the seal) of the solid state relay package shall not be permitted.

NOTE: Packages containing beryllia shall not be ground, sandblasted, machined, or have other operations performed on them which will produce beryllia or beryllium dust. Furthermore, beryllium oxide packages shall not be placed in acids that will produce fumes containing beryllium.

- 3,6.9 <u>Metals</u>. Metal surfaces shall be corrosion resistant or shall be plated or treated to resist corrosion and shall meet the requirements specified in 3.6.12.
- 3.6 10 Other materials. External parts, elements or coatings including markings shall be non-nutrient to fungus and shall not blister, crack, outgas, soften, flow, or exhibit defects that adversely affect storage, operation, or environmental capabilities of solid state relays delivered to this specification under the specified test conditions.
- 3.6 11 Internal conductors (Class II (hybrid) construction only) Internal thin film conductors on a substrate (metallization stripes, contact areas, bonding interfaces, etc.) shall be designed so that no properly fabricated conductor shall experience in normal operation (at worst case specified operating conditions), a current density in excess of the maximum allowable value shown below for the applicable conductor material.

Conductor material	Maximum allowable current density
Aluminum (99.99 percent pure or doped) without glassivation	2 x 10 <sup>5</sup> A/cm <sup>2</sup>
Aluminum (99 99 percent pure or doped) glassivated	5 x 10 <sup>5</sup> A/cm <sup>2</sup>
Gold	6 x 10 <sup>5</sup> A/cm <sup>2</sup>
All other (unless otherwise specified)	2 x 10 <sup>5</sup> A/cm <sup>2</sup>

The current density shall be calculated at the point of maximum current density (1 %., greatest current per unit cross section; see 3.6.11.a) for the specified solid state relay and schematic or configuration

- a. Use a current value equal to the maximum continuous current (at full fanout for digitals or at maximum load for linears) or equal to the simple time-averaged current obtained at maximum rated frequency and duty cycle with maximum load, whichever results in the greater current value at the point of maximum current density. This current value shall be determined at the maximum recommended supply voltage and with the current assumed to be uniform over the entire conductor cross sectional area.
- b Use the minimum allowed metal thickness in accordance with manufacturing specifications and controls including appropriate allowance for thinning experienced in the metallization step (via). The thinning factor over a metallization step is not required unless the point of maximum current density is located at the step.
- c Use the minimum actual design conductor widths (not mask widths) including appropriate allowance for narrowing or undercutting experienced in metal etching
- d Areas of barrier metals and nonconducting material shall not be included in the calculation of conductor cross section

Thick film conductors on hybrid solid state relays or multichip substrates (metallization strips, bonding interfaces, etc.) shall be designed so that no properly fabricated conductor shall dissipate more than 4 watts/cm<sup>2</sup> when carrying maximum design current, (except for conductors on BeO which shall dissipate no more than 80 watts/cm<sup>2</sup>).

- 3.6.12 Package and lead materials and finishes.
- 3 6 12.1 <u>Lead or terminal material</u>. Unless otherwise specified (see 3.1), the lead or terminal material shall conform to one of the following compositions
  - a Type A: Iron-Nickel-Cobalt alloy: MIL-I-23011, class I, ASTM F-15
  - b Type B: Iron-Nickel alloy (41 percent Ni): MIL-I-23011, class 5, ASTM F-30.
  - c. Type C: Co-fired metallization such as nominally pure tungsten. The composition and application processing of these materials shall be subject to qualifying activity approval
  - d Type D Copper core-iron nickel ASTM F-30 alloy (50.5 percent Ni). The core material shall consist of copper (oxygen-free) ASTM B-170, grade 2.
  - e Type E: Copper core ASTM F-15 alloy. The core material shall consist of copper (oxygen-free) ASTM B-170, grade 2.
  - f Type F. Copper (oxygen free) ASTM B-170, grade 2. This material shall not be used as an element of any glass-to-metal seal structure.
  - g. Type G. Iron-Nickel alloy (50.5 percent Ni): MIL-I-23011, class 2 ASTM F-30.
  - h. Type H. Nickel: MIL-N-46025 (for ribbon leads) and MIL-N-46026 (for round wire leads).
- 3 6 12 2 <u>Lead finish</u> The finish system on all external leads or terminals shall conform to one of the following (pure tin finish shall not be used on any internal or external package surface or as a lead finish. In addition, tin plating shall not be used as an undercoat).
  - a. Hot solder dip. The hot solder dip shall be homogeneous with a minimum thickness of 60 microinches (1.52 µm) for round leads and, for other shapes, a minimum thickness at the crest of the major flats of 200 microinches (5 08 µm) solder (SN60 or Sn63). In all cases, the solder dip shall extend up to and beyond the effective seating plane for packages with standoffs or within 030 inch (0.76 mm) of the lead or package interface for leaded flush mounted solid state relays. For leadless chip carrier solid state relays, the hot solder dip shall cover a minimum of 95 percent of the metallized side castellation or notch and metallized areas above and below the notch except the index feature if not connected to the castellation. Terminal area intended for solid state relay mounting shall be completely covered. The hot solder dip is applicable.
    - (1) Over a finish in accordance with entry b or c below, or
    - (2) Over electroplated nickel or electroless nickel phosphorous in accordance with 3.6.12.4.1, or
    - (3) Over the basis metal. When applied over the basis metal, underplate that is nonconforming, or other finishes that are nonconforming (e.g., fused tin less than 200 microinches), hot solder dip shall cover the entire lead to the glass seal or point of emergence of the lead or metallized contact through the package wall.
  - b Tin-lead plate Tin-lead plating shall have in the plated deposit 3 percent to 50 percent by weight lead (balance nominally tin) homogeneously co-deposited. As plated tin-lead shall be a minimum of 300 microinches thick. As plated tin-lead shall contain no more than 0.05 percent by weight co-deposited organic material measured as elemental carbon.

Tin-lead plate is applicable:

- (1) Over electroplated mickel or electroless mickel phosphorous in accordance with 3 6 12 4 1
- (2) Over the basis metal.

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- c. Gold plate. Gold plating shall be a minimum of 99.7 percent gold, and only cobalt shall be used as the hardener. Gold plating shall be a minimum of 50 microinches (1.27 µm) and a maximum of 225 microinches (5.72 µm) thick. Gold plating shall be permitted only over nickel plate or undercoating in accordance with 3.6.12.4.1.
- 3 6.12.3 <u>Solder dip (retinning) leads</u> Only the manufacturer, at their option, may solder dip/retin the leads of the product supplied to this specification provided the solder dip/retin process has been approved by the qualifying activity.
- 3.6.12.3 1 Qualifying activity approval. Approval of the solder dip process will be based on one of the following options:
  - a. When the original lead finish qualified was not solder dip in accordance with 3.6 12.2a. The manufacturer shall use the same solder dip process for retinning as is used in the original manufacture of the product.
  - b. When the lead originally qualified was not hot solder dip as prescribed in (a), approval for the process to be used for solder dip shall be based on the following test procedure:
    - (4) Six samples of any solid state relay of a individual specification sheet and specific lead finish shall be subjected to the manufacturer's solder dip process. Following the test, the solid state relays shall be subjected to the subgroups 2 and 3 tests of the Group A inspection. No process related (solder dip) defects are allowed.
    - (2) Two of the six samples shall be subjected to the solderability test in accordance with 4.7.3. No defects are allowed
    - (3) The remaining four samples are subjected to the resistance to solder heat test and then to the subgroups 2 and 3 tests of the Group A inspection. No process related (solder dip) defects are allowed.
    - (4) In addition, the hot solder dip process must meet requirements of 3.6.12.2a
  - 3.6.12.3.2 Solder dip/retinning options. The manufacturer may solder dip/retin as follows
    - a. After the Group A, subgroup 1, screening tests—Solid state relays shall then be subjected to remaining Group A inspections
    - b As a corrective action, if the lot fails the group A solderability test.
    - After the group A inspection has been completed. Following the solder dip/retinning process, an external visual examination in accordance with subgroup 3 of group A shall be repeated.
- 3 6.12.4 Package body finish. External metallic package elements other than leads or terminals (e.g., lids, covers, bases, seal rings, etc.) shall meet the applicable corrosion resistance and environmental requirements or shall be finished so that they meet those requirements using finishes conforming to one or more of the following as applicable (pure tin finish shall not be used on any internal or external package surface or as a lead finish. In addition, tin plating shall not be used as an undercoat)
  - a Solder in accordance with 3.6.12.2a.
  - b Tin-lead plate in accordance with 3 6.12.2b.
  - Gold plate shall be a minimum of 99 7 percent gold and only cobalt shall be used as a hardener. Gold plating shall be a minimum of 10 microinches (0.25 µm) and a maximum of 225 microinches (5.72 µm) thick. The gold plate shall be applied over electroless or electroplated nickel or undercoating in accordance with 3.6.12 4.1. Multilayered finish structures are acceptable provided the outer gold layer meets the minimum thickness of 10 microinches (0.25 µm) and each of the nickel undercoats meets the thickness requirements of 3.6.12 4.1 with the total nickel thickness not to exceed 600 microinches (15.24 µm)
  - d Nickel plate in accordance with 3 6 12 4 1

- 3.6.12.4.1 Nickel plate or undercoating. Electroplated nickel undercoating or finishes from a sulfammate nickel bath is preferred and shall be 50 to 350 microinches (1.27  $\mu m$  to 8.89  $\mu m$ ) thick measured on major flats or diameters. Electroless nickel undercoating or finishes, when allowed, shall be 50 to 350 microinches (1.27  $\mu m$  to 8.89  $\mu m$ ) thick measured on major flats or diameters. The addition of organic "wetting agents" is prohibited for either sulfammate or phosphorous nickel baths. Electroplate or electroless nickel plate (or combinations thereof) as well as nickel cladding may be used as the finish for package elements other than flexible leads or terminals provided the corrosion resistance and environmental requirements are met. In all cases, electroplated nickel undercoating from a nickel sulfammate bath is preferred for lead finishes. Electroless nickel shall not be used as the undercoating on flexible or semiflexible leads (see 3.3 1 and 3.3.2 of method 2004 of MIL-STD-883) and shall be permitted only on rigid leads or package elements other than leads.
- 3.7 <u>Screening</u> When solid state relays are screened as specified in 4.7.2, they shall meet the requirements as specified in 3.7.1 through 3.7.8.
- 3.7.1 <u>Preseal burn-in (optional)</u>. When solid state relays are tested as specified in 4.7.2.1, they shall show no evidence of physical or mechanical damage. In addition, solid state relays shall be tested in accordance with the electrical characteristics (see 3.12) at 25°C. Nanufacturer may also perform electrical tests at temperature extremes.
- 3.7.2 <u>Internal visual</u>. When solid state relays are tested as specified in 4.7.2.2, they shall meet the requirements as specified.
- 3.7.3 <u>High temperature storage (stabilization bake)</u>. When solid state relays are tested as specified in 4.7.2.3, they shall show no evidence of physical or mechanical damage.
- 3 7 4 <u>Temperature cycling</u>. When solid state relays are tested as specified in 4.7.2 4, they shall show no evidence of physical or mechanical damage.
- 3.7.5 <u>Mechanical shock or constant acceleration</u>. When solid state relays are tested as specified in 4.7.2.5, they shall show no signs of physical or mechanical damage.
- 3.7.6 <u>Load conditioning</u>. When solid state relays are tested as specified in 4.7.2.6, they shall show no signs of physical or mechanical damage.
- 3.7.7 <u>Interim (pre-burn-in) electrical requirements (optional)</u>. When solid state relays are tested as specified in 4.7.2.7, they shall meet the electrical requirements as applicable
- 3.7.8 <u>Burn-in test</u>. When solid state relays are tested as specified in 4.7.2.8, they shall show no signs of physical or mechanical damage
- 3.8 Solderability (applicable to solder terminals). When solid state relays are tested as specified in 4.7.3, the dipped surface of solid wire-lead and pin terminals shall be at least 95 percent covered with a continuous new solder coating. The remaining 5 percent may contain only small pinholes or rough spots; these shall not be concentrated in one area. Bare base metal where the solder dip failed to cover the original coating is an indication of poor solderability, and shall be cause for failure. For solder-lug terminals, 95 percent of the total length of fillet, which is between the standard wrap wire and the terminal, shall be tangent to the surface of the terminal being tested, and shall be free of pinholes, voids, etc. A ragged or interrupted line at the point of tangency between the fillet and the terminal under test shall be considered a failure.
- 3.9 <u>Seal</u>. When tested as specified in  $4_3$ 7.4, there shall be no leakage in excess of 1 x  $10^{-8}$  atmospheric cubic centimeters per second of air (atm cm<sup>3</sup>/s), or as specified (see 3.1)
- 3 10 <u>Insulation resistance</u>. When solid state relays are tested as specified in 4.7.5, the resistance shall be 100 megohms minimum. When specified (see 3.1), the insulation resistance between load circuits and input shall be 50 megohms minimum
- 3 11 <u>Dielectric withstanding voltage</u>. When tested as specified in 4 7.6, solid state relays shall withstand the voltage specified without damage, and there shall be no leakage current in excess of 1 0 milliampere (mA) nor evidence of damage due to arcing (air discharge), flashover (surface discharge), or insulation breakdown (puncture discharge)

- 3.12 <u>Electrical characteristics</u>. Unless otherwise specified, electrical characteristics shall be tested 100% inspection at -55°C, +25°C, and +125°C. Manufacturer has the option for sequence of test temperature (+25°C, -55°C, +125°C), and the sequence in which the electrical characteristics tests are performed.
- 3 12.1 Reverse polarity (DC operated solid state relays) (when specified, see 3 1) When tested as specified in 4.7.7.1, the solid state relay shall not operate or be damaged. Following the test, the turn-on voltage, input current, and turn-off voltage shall be as specified (see 3.1).
- 3 12.2 <u>Input Current (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.7.2.1, the input current shall be as specified (see 3.1).
- 3.12.3 <u>Input turn-on voltage (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.7.2.2, the solid state relay shall operate as specified (see 3.1).
- 3.12 4 <u>Input turn-off voltage (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.7.2.3, the solid state relay shall operate as specified (see 3.1).
- 3.12.5 Bias current (when specified, see 3.1). When solid state relays are tested as specified in 4.7.7.2.4, the bias current shall not exceed the specified value (see 3.1).
- 3.12 6 Control current (when specified, see 3.1). When solid state relays are tested as specified in 4.7.7.2.5, the control current shall not exceed the specified value (see 3.1).
- 3 12.7 Control turn-on voltage (when specified, see 3.1). When solid state relays are tested as specified in 4 7 7.2.6, the solid state relay shall operate as specified (see 3.1)
- 3 12.8 Control turn-off voltage (when specified, see 3 1). When solid state relays are tested as specified in 4.7.7 2.7, the solid state relay shall operate as specified (see 3.1).
- 3 12 9 Overload Will not trip current (short circuit protected solid state relays) (when specified, see 3.1). When solid state relays are tested as specified in 4.7.7 3, the solid state relay shall remain ON for the specified time (see 3.1).
- 3.12 10 Overload Must trip current (short circuit protected solid state relays) (when specified, see 3.1). When solid state relays are tested as specified in 4.7 7 4, the solid state relay shall shut OFF within the specified time (see 3.1).
- 3.12 11 <u>Turn-on into a shorted load (when specified, see 3 1)</u> When solid state relays are tested as specified in 4.7 7.5, the solid state relay shall shut OFF.
- 3.12.12 Shorted load with solid state relay ON (when specified, see 3.1). When solid state relays are tested as specified in 4.7.7.6, the solid state relay shall shut OFF
- 3.12.13 <u>Status turn-on time (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.7.7, the status turn-on time shall not exceed the specified value (see 3.1).
- 3 12.14 Status "ON" voltage (when specified, see 3 1) When solid state relays are tested as specified in 4.7.7.8, the status "ON" voltage shall be within specification (see 3.1)
- 3 12 15 <u>Status turn-off time (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7 7 9, the status turn-off time shall not exceed the specified value
- 3 12 16 Status "OFF" voltage (when specified, see 3 1) When solid state relays are tested as specified in 4 7.7 10, the status "OFF" voltage shall be within specification (see 3 1)
- 3 12 17 <u>Status blocking voltage (when specified, see 3.1)</u> When solid state relays are tested as specified in 4.7.7.11, the status (off) current shall not exceed the specified value.
- 3 12 18 Status leakage current (when specified, see 3 1) When solid state relays are tested as specified in 4 7.7 12, the status leakage current shall not exceed the specified value.

- 3.12.19 <u>Turn-on time</u>. When solid state relays are tested as specified in 4.7.7.13, the turn-on time shall not exceed the specified value (see 3.1)
- 3.12.20 <u>Turn-off time</u>. When solid state relays are tested as specified in 4 7.7.14, the turn-off time shall not exceed the specified value (see 3.1)
- 3.12.21 <u>Output voltage drop</u>. When solid state relays are tested as specified in 4.7.7.15, the output voltage drop shall not exceed the value specified (see 3.1).
- 3.12.22 <u>Output leakage current</u>. When solid state relays are tested as specified in 4.7.7.16, the leakage current in the output circuit shall not exceed the specified value (see 3.1).
- 3.12.23 <u>Transient Voltage (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7 7 17, the output shall not turn on. (see 3.1)
- 3.12.24 <u>DC offset voltage (AC solid state relays only) (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.7.18, the DC offset voltage shall not exceed the specified value (see 3.1).
- 3 12.25 <u>Waveform distortion (AC solid state relays only) (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7 7.19, the waveform distortion (commutation spikes) shall not exceed the specified value (see 3.1).
- 3 12.26 <u>Minimum Load current rating (AC solid state relays only) (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.7 20, the solid state relay shall remain ON.
- 3.12.27 Exponential rate of voltage rise (when specified, see 3.1). When solid state relays are tested as specified in 4.7.7.21, they shall withstand the specified rate of voltage rise (see 3.1).
- 3 12.28 Zero crossover (AC solid state relays only) (when specified, see 3.1). When solid state relays are tested as specified in 4.7.7.22, the solid state relay turn-on shall occur within the specified (see 3.1) zero voltage crossover, and solid state relay turn-off shall occur within the specified (see 3.1) zero current crossover.
- 3 12.29 <u>Electrical system spike (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.7.23, they shall withstand the voltage specified without damage.
- 3.12.30 Overload (non-short circuit protected solid state relays only) (when specified, see 3.1). When solid state relays are tested as specified in 4.7.7.24, they shall withstand the specified overload without damage.
- 3.12.31 <u>Electromagnetic interference (when specified, see 3.1)</u> When solid state relays are tested as specified in 4.7.7.25 the conducted emission shall not exceed the specified value (see 3.1).
- 3.12.32 <u>Power dissipation (when specified, see 3.1)</u> When solid state relays are tested as specified in 4.7.7.26, the power dissipation value shall not exceed the specified value (see 3.1)
- 3 13 Resistance to solvents. When solid state relays are tested as specified in 4 7 8, the marking shall remain legible.
- 3.14 <u>Shock (specified pulse)</u> When solid state relays are tested as specified in 4.7.9, there shall be no evidence of physical or mechanical damage.
- 3 15 <u>Vibration</u> When solid state relays are tested as specified in 4 7 10, there shall be no evidence of physical or mechanical damage
- 3 16 <u>Terminal strength</u> When solid state relays are tested as specified in 4 7 11, there shall be no evidence of loosening or breaking of the terminals, and there shall be no deformation to the threads of screw terminals, no damage to the insulating base of plug-in solid state relays, nor shall there be any other damage which would adversely affect the normal operation of the solid state relay. Bending of solder terminals shall not be construed as damage, bending of plug-in terminals shall not be construed as damage, provided they can be reformed in a manner to permit proper mating with the applicable sockets

3 17 Moisture resistance (applicable to nonhermetically seeled solid state relays only). When solid state relays are tested as specified in 4.7 12, there shall be no evidence of breaking, cracking, chipping or flaking of the finish, or loosening of the terminals. After the 24-hour drying period, solid state relays shall meet the following requirements:

- 3.18 <u>Crosstalk (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.13, the attenuation shall be a minimum of 20 decibels (dB).
- 3.19 <u>Isolation (when specified, see 3.1)</u>. When solid state relays are tested as specified in 4.7.14, the capacitance shall not exceed the value specified.
- 3.20 Resistance to soldering heat (when specified, see 3.1). When solid state relays are tested as specified in 4.7.15, there shall be no damage which would adversely affect normal operation of the solid state relays.
- 3.21 <u>Salt spray (corrosion)</u>. When solid state relays are tested as specified in 4.7.16, there shall be no evidence of breaking, cracking, chipping or flaking of the finish, nor exposure of base metal due to corrosion which would adversely affect the application or performance characteristics of the solid state relays
- 3.22 <u>Life</u>. When solid state relays are tested as specified in 4.7.17, there shall be no damage which would adversely affect normal operation of the solid state relays.
- 3.23 <u>Marking</u>. All applicable marking shall appear on a surface visible when solid state relay is mounted in its normal position.
- 3.23.1 "JAN" brand. The United States Government has adopted, and is exercising legitimate control over the certification marks "JAN" and "J", respectively to indicate that items so marked or identified are manufactured to, and meet all the requirements of military specifications. Accordingly, items acquired to, and meeting all of the criteria specified, herein and in applicable specifications shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed on the first line above or below the part number or the "J" with the date code (example: J9230). Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein or in applicable specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable specification sheets or associated detail specifications, the manufacturer shall remove the "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration No 504,860 for the certification mark "JAN"

- 3 23.2 <u>Identification marking (full)</u>. Solid state relays shall be marked in accordance with MIL-STD-1285, with the following information as a minimum:
  - a. Military PIN, including a 'Y' to indicate screening level (see 1.3 and 3.1). The 'JAN' or 'J' shall not be marked in front of the military PIN.

  - c. Rated input voltage
  - d. Rated output voltage (or current).
  - e. Circuit diagram
  - f. Terminal marking (see 3.6.5).
  - g. Date code (at the option of the manufacturer the "J" with the date code may be used instead of b).
  - h. Manufacturers name or CAGE code.
  - 1. Lot symbol.
  - ESD sensitivity identifier, (see 3.23.4)
- 3.23.3 <u>Minimum marking (when specified, see 3.1)</u>. When space does not permit the marking specified in 3.23.2, the marking shall include, as a minimum, the military part number including a 'Y' to indicate screening level, 'J' with date code (example 'J9230'), circuit diagram, manufacturers name or CAGE code, and ESD identifier. The circuit diagram may also be eliminated provided that it appears in the solid state relay specification
- 3 23 4 <u>Electrostatic discharge (ESD) sensitivity identifier</u> The solid state relay shall be marked with a sensitive electronic device symbol as specified in MIL-STD-1285, or if room does not permit, the outline of an equilateral triangle (i e.  $\Delta$ ) shall be used and may also be used as a pin 1 identifier. The equilateral triangle will designate these solid state relays as sensitive to ESD in the range of 0 1,999 volts and shall be handled as such
- 3.23.5. <u>Beryllium oxide package identifier</u> If a solid state relay package contains beryllium oxide, the solid state relay shall be marked with the designation 'BeO'.
- 3.24 <u>Workmanship</u> Solid state relays shall be manufactured and processed in a careful and workmanlike manner, in accordance with good design and sound engineering practices, and to the requirements of this specification. They shall be free of cracked or displaced parts, sharp edges, burrs, and other defects that would affect life or serviceability.
  - 4 QUALITY ASSURANCE PROVISIONS
- 4.1 Responsibility for inspection Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

- 4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspections set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.
- 4.1.2 <u>Test equipment and inspection facilities</u>. Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the manufacturer. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-STD-45662.

### 4.1.3 Quality

- 4.1.3 1 <u>Product assurance program</u> A product assurance program shall be established to meet the requirements of MIL-STD-790 and as specified herein (see 3.3.1). Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.
- 4.1.3.2 <u>Statistical process control</u>. A statistical process control (SPC) program shall be established and maintained in accordance with EIA-557. Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.
- 4.1.3.3 <u>Traceability requirements</u>. The manufacturer shall submit to the qualifying activity the procedure, whereby the lot date codes are assigned, that incorporates traceability. The following is a list of raw material/component parts and subassembly traceability requirements, and is not inclusive and may be modified at the discretion of the qualifying activity:
  - a Substrates.
  - b. All active and passive elements.
  - Wire used internally during circuit completion
  - d All inks, epoxies, etc
  - e Heeder.
  - 4.2 <u>Classification of inspections</u> The inspections specified herein are classified as follows.
    - a Qualification inspection (see 4.4)
    - b Retention of qualification (see 4.5).
    - c Quality conformance inspection (see 4-6)
- 4.3 <u>Inspection conditions</u>. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-883 and MIL-STD-202
- 4 3.1 <u>Power supply</u> Unless otherwise specified herein, the power supply shall have no more than 5 percent regulation at 110 percent of the specified test current. A DC power supply shall have no more than 5 percent ripple voltage. An AC power supply shall be within 1 percent of the specified frequency and shall be sinusoidal with a form factor between 0.95 and 1 25
- 4 3 1 1 <u>Grounding</u> Unless otherwise specified (see 3 1), the negative side of the DC power supply shall be grounded, one side of single-phase AC power supply shall be grounded, or the neutral of 3-phase AC power supply shall be grounded, as applicable

- 4.3.2 <u>Load conditions during tests</u>. The input of the solid state relay being tested shall be connected to the grounded side of its power supply, each load of the solid state relay being tested shall be connected to the grounded side of its power supply; and each output shall be connected to an individual load Separate power supplies shall be used for the input to the solid state relay and the individual load being tested.
- 4.4 <u>Qualification inspection</u> Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample solid state relays produced with equipment and procedures normally used in production.

TABLE I. Qualification inspection.

Paragraph   Paragraph   Per gro		TABLE 1. AND THE PROPERTY.				
Electrical system spike   3.12.29   4.7.7.23   12     Overload   3.12.30   4.7.7.24     Power dissipation   3.12.32   4.7.7.26     Visual and mechanical inspection   3.1, 3.4, 3.6, 4.7     Group II	Inspection	•	•			
Overload   3.12.30	Group I .					
Power dissipation   3.12.32   4.7.7.26     Visual and mechanical inspection   3.1, 3.4, 3.6, 4.7.1     Group II	Electrical system spike	3.12.29	4.7.7.23	12		
Visual and mechanical inspection	) - · - · · - · - ·		4.7.7.24	1		
Shock (specified pulse)   3.13   4.7.8   4				1		
Resistance to solvents   3.13   4.7.8   4	Visual and mechanical inspection -		4.7 1	1		
Resistance to solvents   3.13		3.23 and 3.24	İ	ļ		
Shock (specified pulse)	Group II		!			
Shock (specified pulse)	Resistance to solvents	3.13	l l 4.7.8	4		
Vibration   3.15				i		
Terminal strength   3 16				i		
Temperature cycling   3 7.4   4 7 2.4     Seal   3.9   4 7 4     Moisture resistance   3.17   4 7.12     Insulation resistance   3.10   4 7.5     Dielectric withstanding voltage -   3 11   4 7.6     Electrical characteristics 1/   3 12   4 7 7     Visual and mechanical inspection -   3 1, 3.4, 3.6, 4.7.1     Group III				Ì		
Seal   3.9   4.7.4     Monsture resistance   3.17   4.7.12     Insulation resistance   3.10   4.7.5     Dielectric withstanding voltage -   3.11   4.7.6     Electrical characteristics 1/   3.12   4.7.7     Visual and mechanical inspection -   3.1, 3.4, 3.6, 4.7.1     Group III	Temperature cycling	3 7.4		i		
Moisture resistance   3.17			,	1		
Insulation resistance			,	j		
Electrical characteristics 1/   3 12	Insulation resistance			i		
Electrical characteristics 1/   3 12	Dielectric withstanding voltage -	3 11	4 7.6	İ		
Visual and mechanical inspection -   3 1, 3.4, 3.6,   4.7.1			477	i		
3.23 and 3 24			4.7.1	i		
	·		İ	ĺ		
Isolation 3.19 4.7.14	Group III		1	į		
Isolation 3.19 4.7.14	Crosstalk	3 18	   4 7 13	4		
		•		1		
			4.7.15	i		
Sait spray (corrosion)   3.21   47.16				i		
Insulation resistance   3 10   4 7.5				ì		
Dielectric withstanding voltage -   3 11   4 7.6				i		
Electrical characteristics 1/   3.12   4.7.7			4.7.7	i		
	Seal	3.9	4.7.4	i		
Visual and mechanical inspection - 31, 34, 36, 4.7.1	Visual and mechanical inspection -	31, 34. 36,	4.7.1	i		
3.23 and 3.24	•	3.23 and 3.24		İ		
Group IV	Group IV			į		
  L1fe	L1fe	3.22	4.7.17	   <b>4</b>		
Insulation resistance 3.10 4.75	<del></del>			i		
Dielectric withstanding voltage -   3.11   4.7.6				i		
Electrical characteristics   3.12   47.7		,		i		
Seal   3.9   4.7.4				ŀ		
Visual and mechanical inspection -   3.1, 3 4, 3.6,   4.7 1	Visual and mechanical inspection -			ĺ		
3 23 and 3.24						

<sup>1/</sup> Electromagnetic interference shall not be performed

- 4.4.1 <u>Sample size</u>. The number of solid state relays to be subjected to qualification inspection shall be 12. In addition, submit one unsealed sample to the qualifying activity as part of the qualification procedure. The sample solid state relays shall be taken at random from a production run and shall be produced with equipment and procedures normally used in production, and which have been subjected to and passed the requirements of group A inspection (see 4.6.1.2). Qualification shall not be granted if group A inspection requirements are not complied with
- 4.4.2 <u>Inspection routine</u> Qualification samples shall be subjected to the tests as specified in table I, in the order shown, as applicable for each solid state relay. All sample units shall be subjected to group I. The sample units shall then be divided into three groups of four and shall then be subjected to group II, III, and IV.
- 4.4.3 <u>Failures</u>. No failures shall be allowed for Group I, and only one failure shall be allowed for Groups II, III, and IV combined Failures in excess of those allowed shall be cause for refusal to grant qualification approval.
- 4.5 <u>Retention of qualification</u> To retain qualification, the contractor shall forward a report for Groups A and B inspection every 6 months and every 24 months for Group C. The qualifying activity shall establish the initial reporting date. The report shall consist of
  - a A summary of the results of the tests performed for inspection of product for delivery (Group A), indicating as a minimum the number of lots that have passed and the number that have failed. The results of tests of all reworked lots shall be identified and accounted for
  - b. A summary of the results of test performed for inspection (groups B and C), including the number and mode of failures. The summary shall include results of all periodic inspection tests performed and completed during the reporting period. If the summary of the test results indicates nonconformance with specification requirements, and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list.

Failure to submit the report within 60 days after the end of each reporting period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the contractor shall immediately notify the qualifying activity at any time that the inspection data indicates noncompliance of the product to meet the requirements of this specification.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the solid state relay. If during two consecutive reporting periods, (6 month reporting period as defined in paragraph 4.5 above), there has been no production, the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative sample of solid state relays of each specification sheet to testing in accordance with the qualification inspection requirements.

- 4 6 Quality conformance inspection.
- 4 6 1 <u>Inspection of product for delivery</u> Inspection of product for delivery shall consist of group A inspection.
  - 4.6 1 1 Production and inspection lot.
- 4 6 1 1 1 <u>Production Lot</u> A production lot shall consist of all solid state relays covered by a single specification sheet and single part number. Manufacture of all solid state relays in the lot shall have been started, processed, assembled, and tested as a group. Lot identity shall be maintained throughout the manufacturing cycle.
- 46112 <u>Inspection lot</u> A inspection lot shall consist of all solid state relays covered by a single specification sheet, produced and sealed under essentially the same conditions, and offered for inspection at one time within a period not to exceed 1 month.
- 4 6 1 2 <u>Group A inspection</u> Group A inspection shall consist of the inspections specified in table II, in the order shown

- 4.6.1.2.1 <u>Sampling plan (subgroups 1, 2, and 3)</u>. The tests performed in subgroups 1, 2, and 3 shall require 100 percent inspection, except only two units per production lot shall be tested for DC offset voltage, waveform distortion, and minimum current ratings. Defective solid state relays shall be removed from the production lot. If, during the 100 percent inspection of subgroup 2 over 5 percent of the solid state relays are discarded, the production lot shall be rejected. The rejected production lot may be resubmitted for subgroup 2 rescreening provided they meet the following criteria:
  - a. The observed percentage defective allowed (PDA) does not exceed twice the specified PDA.
  - b. The cause of failure has been evaluated and determined
  - c. The failure was due to random causes/or, for pattern failures, appropriate and effective corrective action has been completed to reject all solid state relays affected by the failure cause.
  - d. Appropriate preventive action has been initiated.
  - e. The failure shall not have the potential to cause any latent field failure on the remaining solid state relays
  - f The preceding conditions shall not apply in those cases (instances) where the failures can be directly attributed to random equipment failure and/or operator error, with qualifying activity consumments.
- 4 6.1.2.2 <u>Sampling plan (subgroup 4)</u>. Two samples shall be selected randomly from each inspection lot and subjected to the subgroup 4 solderability test. The manufacturer may use electrical rejects from the subgroup 2 screening tests for all or part of the samples to be used for solderability testing. If there is one or more defects, the lot shall be considered to have failed
- 4.6 1.2.2.1 Rejected lots (subgroup 4). In the event of one or more defects, the inspection lot is rejected. The manufacturer may use one of the following options to rework the lot:
  - a. Each production lot that was used to form the failed inspection lot shall be individually submitted to the solderability test as required in 4.6.1.2. Production lots that pass the solderability test are available for shipment. Production lots failing the solderability test can be reworked only if submitted to the solder dip procedure in (b)
  - b The manufacturer submits the failed lot to a 100 percent solder dip using an approved solder dip process in accordance with 3.6.12.2m Following the solder dip process, the Subgroups 2, 3, and 4 Group A inspections shall be repeated on the lot. If the lot fails the Subgroup 2 PDA requirement or fails the Subgroup 4 solderability test, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.
- 4.6 1 2 3 <u>Disposition of samples</u> The solderability test is considered a destructive test and samples submitted to the solderability test shall not be supplied on the contract.

TABLE II. Group A inspection.

Inspection	Requirement   paragraph	Test method paragraph	   Sampling   procedure
Subgroup 1			
Screening	3.7	4.7.2	4 6.1.2.1
<u>Subgroup 2 1/, 2/</u>	 		
  Insulation resistance	3.10 3.11 3.12	4.7.5 4.7.6 4.7.7	4 6 1.2.1
Subgroup 3 4/, 5/   Seal	3 9 3.1, 3.4, 3.6, 3 23 and 3.24	4.7 4 4.7.1	4.6.1.2.1
  Solderability	3.8	4.7.3	4 6.1.2.2

- 1/ Testing sequence optional for insulation resistance and dielectric withstanding voltage
- 2/ Transient voltage and exponential rate of voltage rise (dv/dt) shall be performed at +25°C ambient.
- 3/ Electrical characteristic testing shall not include the following: Electrical system spike, overload, electromagnetic interference, and power dissipation
- 4/ Physical dimensions and weight shall be measured on two sample units per lot
- 5/ Minor defects, such as marking, may be reworked.
- 4.6 2 <u>Periodic inspections</u> Periodic inspections shall consist of groups B and C. Except where the results of these inspections show noncompliance with the applicable requirements (see 4 6.2.2.4), delivery of products which have passed group A shall not be delayed pending the results of these periodic inspections.
- 4 6 2 1 Group B inspection. Group B inspection shall consist of the tests specified in table III and shall be made on sample units which have been subjected to and have passed the group A inspection.
- 4.6 2 1.1 <u>Sampling plan</u> Four sample units from each specification sheet shall be selected every 6 months from sample solid state relays which have passed group A inspection. No failures shall be allowed
- 4 6 2.1 2 <u>Disposition of sample units</u> Sample units which have been subjected to group B inspection shall not be delivered on the contract or purchase order
- 4 6 2 2 <u>Group C inspection</u> Group C inspection shall consist of the tests specified in table I, in the order shown <u>Group C inspection</u> shall be made on sample units selected from inspection lots which have passed the group A inspection
- 4 6 2 2 1 <u>Sampling plan</u> Twelve (12) sample solid state relays of the same part number as originally qualified shall be selected 24 months after the date of every notification of qualification, and after each subsequent 24-month period.
- 4.6 2 2 2 Failures. Failures in excess of those allowed in table I shall be cause for removal of qualification

- 4.6.2.2.3 <u>Disposition of sample units</u>. Sample units which have been subjected to group C inspection shall not be delivered on the contract or purchase order.
- 4 6 2 2 4 Noncompliance If a sample fails to pass the group B or C inspection, the manufacturer shall notify the qualifying activity and the cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same materials and processes, and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the qualifying activity has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspections, or the inspection which the original sample failed, at the option of the qualifying activity). Groups A and B inspections may be reinstituted; however, final acceptance and shipment shall be withheld until the group C inspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure shall be furnished to the cognizant inspection activity and the qualifying activity.
- 4 6 3 <u>Inspection of packaging</u>. The sampling and inspection of the preservation and interior pack marking shall be in accordance with the groups A and B quality conformance inspection requirements of MIL-P-116. The sampling and inspection of the packing and marking for shipment and storage shall be in accordance with the quality assurance provisions of the applicable container specification and the marking requirements of MIL-STD-129.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units	Number of failures allowed
Vibration	j   3.15	4.7 10	4	i i o
Terminal strength	3.16	4 7.11	İ	Ì
Moisture resistance	3.17	4 7 12	i	İ
Insulation resistance	3.10	4 7.5	į	ĺ
Electrical characteristics	3.12	1477	j	İ
Seal	3.9	4.7.4	İ	ĺ
Visual and mechanical inspection -	3 1, 3.4, 3.6, 3.23 and 3.24	4.7.1	ļ	

TABLE III. Group B inspection.

# 4 7 Methods of inspection.

- 4.7.1 <u>Visual and mechanical inspection</u> Solid state relays shall be examined to verify that the materials, external design and construction, physical dimensions, marking and workmanship are in accordance with the applicable requirements (see 3.1, 3.4, 3.6, 3.23 and 3.24).
- 4.7 2 Screening (see 3.7). Solid state relays shall be screened in accordance with 4.7.2.1 through 4.7.2.8
- 4 7 2 1 <u>Preseal burn-in (optional) (see 3 7 1)</u>. Solid state relays shall be tested in accordance with method 1030 of MIL-STD-883
- 4 7.2 2 <u>Internal visual (see 3 7.2)</u> Solid state relays shall be tested in accordance with method 2017 of MIL-STD-883
- 4 7 2 3 <u>High temperature storage (stabilization bake) (see 3 7 3)</u> Solid state relays shall be tested in accordance with method 1008 of MIL-STD-883 Unless otherwise specified, test condition B and a time duration of 24 hours shall apply

- 4.7.2 4 <u>Temperature cycling (see 3.7.4)</u> Solid state relays shall be tested in accordance with method 1010 of MIL-STD-883. Unless otherwise specified, test condition B shall apply. The following details shall apply.
  - a Special mounting: Solid state relays shall be suspended in the test chamber by nonheat-conducting material, in a plane parallel to the normal air flow. Test leads may be used for mounting; however, they shall not provide a heat sink.
  - b Number of cycles: 100 for qualification inspection and 10 for quality conformance inspection
  - 4 7.2.5 Mechanical shock or constant acceleration (see 3 7 5).
    - a. Mechanical shock Solid state relays shall be tested in accordance with method 2002, test condition B, of MIL-STD-883. Y1 direction only.
    - b. Constant acceleration Solid state relays shall be tested in accordance with method 2001, test condition A, of MIL-STD-883. Y1 direction only
- 4.7.2.6 Load conditioning (see 3.7.6). Solid state relays shall be cycled by applying a step function voltage to the input; the input shall be energized at zero or rated input voltage. The load shall be maximum rated current, without auxiliary heat sink, and each output circuit shall be loaded with the maximum rated resistive current at the highest rated voltage, for 3 hours, at a rate no less than 1, nor more than 30 operations per second. When applicable (see 3.1), the bias shall be applied at the rated value. The solid state relay shall be turned off 10 percent of the time and turned on 90 percent of the time. For SPDT and DPDT solid state relays, cycling shall be 50 percent turned on and 50 percent turned off, or for 1.5 hours of test, 10 percent on and 90 percent off, and 90 percent on and 10 percent off for 1.5 hours of test
- 4 7.2.7 <u>Interim (pre-burn-in) electrical requirements (see 3.7.7)</u> The interim (pre-burn-in) electrical requirements may be performed at the option of the manufacturer <u>Electrical parameters tested shall be</u> those specified in 3 12, as applicable
- 4.7.2.8 <u>Burn-in test (see 3.7.8)</u>. Unless otherwise specified (see 3.1), solid state relays shall be subjected to 160 +8/-0 hours of operation at the maximum operating temperature. At the option of the manufacturer, the burn-in time-temperature regression table of method 1015 of MIL-STD-883, may be used Lower temperatures at higher load currents, in accordance with the specified derating curve, may be used with qualifying activity approval. Input and bias (where applicable) shall be at the rated ON state conditions. The output(s) shall be loaded with the maximum specified current derated for the test temperature. Output condition shall be monitored with latching failure circuitry and appropriate indicators. If scanning type condition monitoring is employed, each solid state relay shall be monitored at least once per second throughout the entire burn-in period.

Test conditions shall be measured on one randomly selected socket prior to start of the test. The values, the test temperature and start time shall be recorded on a burn-in log. At the completion of the test prior to removal of bias, the test conditions shall be measured on one randomly selected socket. The values, the temperature and the finish time shall be recorded on the burn-in log.

Any solid state relays that fail during the burn-in shall be removed from the lot at the completion of burn-in. If the test conditions are interrupted for more than ten (10) minutes during the test (for example, due to equipment malfunction or power outages), the test duration shall be extended to ensure that actual exposure time is 160 +8/-0 hours. Any such interruptions in the final eight (8) hours of test shall require an extension of the test duration for eight (8) hours following the last interruption.

- 4 7 3 Solderability (applicable to solder terminals) (see 3 8) Solid state relays shall be tested in accordance with method 208 of MIL-STD-202. All terminations of each solid state relay shall be tested
- 4 7 4 <u>Seal (see 3 9)</u> Solid state relays shall be tested in accordance with 4 7 4 1 or 4 7 4.2 as applicable. In case of dispute, method 1014 of MIL-STD-883, test condition B shall govern

- 4.7.4.1 <u>Solid state relays sealed with a tracer gas</u>. Solid state relays sealed with a tracer gas shall be tested in accordance with method 112 of MIL-STD-202 (4.7.4.1a) or method 1014 of MIL-STD-883 (4.7.4.1b) The following details shall apply:
  - a Method 112 of MIL-STD-202:
    - (1) Test condition C, procedure IV. Solid state relays shall be back filled with a helium tracer gas (90 percent dry gas and 10 percent helium). For gross leak, silicone oil shall not be used.
    - (2) Leakage rate sensitivity:  $1 \times 10^{-8}$  atm cm<sup>3</sup>/s.
    - (3) Measurements after test: Not applicable.
  - b Method 1014 of MIL-STD-883, test condition A or test condition B.
- 4.7.4.2 <u>Solid state relays sealed without a tracer gas</u>. Solid state relays sealed without a tracer gas shall be tested in accordance with method 1014 of MIL-STD-883. At the option of the manufacturer, either "a" or "b" may be used. The following details shall apply.
  - a. Method 1014 of MIL-STD-883:
    - (1) Test condition A1 or A2.
    - (2) Measurements after test. Perform a gross leak test in accordance with method 112 of MIL-STD 202, test condition A, B, or D. Silicone oil shall not be used. At the option of the manufacturer, the gross leak test of method 1014 of MIL-STD-883, test condition C, may be used.
  - b. Method 1014 of MIL-STD-883, test condition B.
- 4.7.4.3 <u>Radioisotope dry gross leak test (optional)</u>. This test shall be used only to test solid state relays that internally contain some krypton-85 absorbing medium, such as electrical insulation, organic, or molecular sieve material. This test shall be permitted only if the following requirements are met:
  - a A 5 to 10 mil diameter hole shall be made in a representative unit of the solid state relay to be tested. (This is a one time test that remains in effect until a design change is made in the solid state relay internal construction.)
  - b The solid state relay shall be subjected to this test condition. If the solid state relay exhibits a hard failure, this test condition may be used for those solid state relays represented by the test unit. If the solid state relay does not fail, this test shall not be used and instead a +125°C fluorocarbon gross leak shall be performed in accordance with MIL-STD-202, method 112, test condition D, except the specimen shall be observed from the instant of immersion for 1 minute minimum to 3 minutes maximum.
  - 4.7.4.3 1 Apparatus. The following apparatus shall be required for this test:
    - a. Radioactive tracer gas activation console containing krypton-85/dry nitrogen gas mixture.
    - b Counting station with sufficient sensitivity to determine the radiation level of krypton-85 tracer gas inside the solid state relay
    - c. Tracer gas mixture: Krypton-85/dry nitron with a minimum allowable specific activity of 100 microcuries per atmosphere cubic centimeter. The specific activity of the krypton-85/dry nitrogen mixture shall be a known value and determine on a once-a-month basis as a minimum

- 4.7.4.3.2 <u>Procedure</u> The solid state relays shall be placed in a radioactive tracer gas activation tank and the tank shall be evacuated to a pressure not to exceed 0.5 torr. The solid state relays shall then be subjected to a minimum of 10 psig of krypton-85/dry nitrogen gas mixture for 30 seconds. The gas mixture shall then be evacuated in storage until a pressure of 2.0 torr maximum exists in the activation tank. The evacuation shall be completed in 5 minutes maximum. The evacuation tank shall then be backfilled with air (air wash). The solid state relays shall then be removed from the activation tank and leak tested within 2 hours after gas exposure with a scintillation-crystal-equipped counting station. Solid state relays indicating 1,000 counts per minute or greater above the ambient background of the counting station shall be considered a gross leak failure.
- 4.7.5 <u>Insulation resistance (see 3.10)</u>. Solid state relays shall be tested in accordance with method 1003 of MIL-STD-883. The following details and exceptions shall apply.
  - a. Test condition: E
  - b. Points of measurement:
    - A common connection of each input circuit and every other isolated input circuit, if applicable.
    - (2) When specified (see 3.1), a common connection of all input terminals, and a common connection of all output terminals. Unless otherwise specified (see 3.1), the voltage shall be 500 volts, and the input shall be positive with respect to the output.
    - (3) A common connection of the terminals of each output pole, and a common connection of all other isolated output terminals
  - c Electrification time: 2 minutes, or until a stable reading is obtained.
- 4.7.6 <u>Dielectric withstanding voltage (see 3.11)</u> Solid state relays shall be tested as specified in 4.7.6.1, and when specified (see 3.1), in accordance with 4.7.6.2.
  - NOTE To avoid unnecessary failures, test voltages shall not be applied indiscriminately. Before beginning test, short-circuit connections shall be made between any set of non isolated input or output terminals in which there is a possibility that the solid state relay will be damaged if the test voltage is applied between them.
- 4.7.6 1 At atmospheric pressure. Solid state solid state relays shall be tested in accordance with method 301 of MIL-STD-202. The following details shall apply
  - a. Magnitude of test voltage As specified (see 3.1)
  - b Nature of potential As specified (see 3.1).
  - c Points of application: Chassis ground, if applicable, and a common connection of all other terminals.
  - d. Maximum leakage current 1.0 milliampere (mA)
  - e Test time shall be 60 sec for qualification testing and for all other testing at the specified (see 3.1) dielectric voltage. If the test voltage is increased to 5% above the specified (see 3.1) voltage, the test time shall be 15 seconds.
  - f. Following these tests, solid state relays shall be examined for evidence of arcing, flashover, insulation breakdown, and damage

- 4.7 6.2 At reduced barometric pressure. Solid state relays specified (see 3.1) for operation above 10,000 feet shall be tested in accordance with method 105 of MIL-STD-202. The following details shall apply
  - a. Method of mounting: Normal mounting means.
  - b. Test condition: C (unless otherwise specified) (see 3.1).
  - c. Tests during subjection to reduced pressure: As specified in 4.7.6 1, except test voltage shall be 1/3 of specified magnitude.
  - d. Same as 4.7.6.1 e.

### 4.7.7 Electrical characteristics.

# 4.7.7.1 Reverse polarity (DC operated solid state relays) (see 3.12 1).

- A. Input configuration
  - 1. Test set up per figure 1.
  - 2. Apply specified (see 3.1) load, voltage, and frequency (if applicable).
  - Remove input voltage, and status voltage (if applicable), and reapply the specified (see 3 1) voltage in reverse polarity between input and input ground.
  - 4 Verify that the reverse input current I(in) is below the specified (see 3.1) value
  - 5 Observe the output for any sign of turn on by measuring V(output)
- B Control configuration
  - 1 Test set up per figure 1.
  - 2. Apply specified (see 3.1) load, voltage, and frequency (if applicable)
  - 3 Remove all input voltages (bias, control, and status if applicable). Apply the specified (see 3.1) voltage in reverse polarity between the specified (see 3.1) terminals
  - 4. Verify that the reverse input current I(in) is below the specified (see 3 1) value
  - 5 Observe the output for any sign of turn on by measuring V(output)

### 4.7 7 2 Input Characteristics.

### 4 7.7 2 1 Input current (see 3 12 2)

- a Test set up per figure 1
- b Apply specified (see 3.1) load, voltage, and frequency (if applicable).
- c. Apply maximum input voltage V(in).
- d. Verify that input current I(in) is within specification (see 3.1)

# 4.7.7 2.2 <u>Input turn-on voltage (see 3.12.3)</u>.

- a Test set up per figure 1.
- b Apply the specified (see 3.1) load, voltage, and frequency (if applicable).
- c. Apply specified (see 3.1) input turn-on voltage (Vin).
- d. Verify that the solid state relay is ON by measuring the output current I(output), or by measuring output voltage drop V(output).

# 4.7.7.2.3 Input turn-off voltage (see 3.12 4)

- a Test set up per figure 1.
- b. Apply specified (see 3.1) load, voltage and frequency (if applicable).
- c Apply specified (see 3.1) input turn-on voltage (Vin) to turn the solid state relay ON. Then apply specified (see 3.1) input turn-off voltage (Vin).
- d Verify that the solid state relay is OFF by measuring the output current I(output) to be within leakage current specification (see 3.1), or by measuring the output voltage V(output).

# 4.7 7.2.4 Bias current (see 3.12 5).

- a. Test set up per figure 1.
- b. Apply specified (see 3.1) load, voltage, and frequency (if applicable).
- c. Apply maximum bias voltage, V(bias), then the specified (see 3 1) control voltage, V(control), to energize the bias current.
- d. Verify that bias current I(bias) is within specification (see 3.1)

# 4.7 7.2.5 Control current (see 3.12 6)

- a. Test set up per figure 1.
- b. Apply specified (see 3.1) load, voltage, and frequency (if applicable)
- c Apply specified (see 3.1) bias voltage V(bias), and apply specified (see 3.1) control voltage V(control)
- d. Verify that control current, I(control), is within specification (see 3.1).

# 4 7.7.2.6 Control turn-on voltage (see 3.12.7)

- a Test set up per figure 1
- b Apply the specified (see 3 1) load, voltage, and frequency (if applicable)
- c Apply the specified (see 3.1) bias voltage, V(bias), and the specified (see 3.1) Control Turn-On voltage, V(control) to turn the solid state relay on
- d Verify that the solid state relay is ON by measuring the output current I(output), or by measuring output voltage drop V(output)

### 4 7 7.2 7 Control turn-off voltage (see 3.12.8).

- a Test set up per figure 1
- b Apply the specified (see 3.1) load, voltage, and frequency (if applicable).
- c. Apply the specified (see 3.1) bias voltage, V(bias), and Control Turn-On voltage to turn the solid state relay on. Then apply specified (see 3.1) Control Turn-Off voltage to turn the solid state relay OFF
- d. Verify that the solid state relay is OFF by measuring the output current I(output) to be within leakage current specification (see 3.1), or by measuring the output voltage V(output).

# 4 7.7.3 Overload - Will not trip current (see 3.12.9).

- a. Test set up per figure 1
- b. Apply the specified (see 3.1) will not trip current, and frequency (if applicable).
- c. Apply specified (see 3.1) input conditions for the specified (see 3.1) will not trip time.
- d. Verify that the solid state relay remains ON for the specified (see 3.1) time by observing the output current I(output), or the output voltage V(output)
- e. Verify that the solid state relay meets the trip characteristics at the various current levels specified (see 3.1)

### 4774 Overload - Must trip current (see 3.12.10).

- a. Test set up per figure 1.
- b. Apply the specified (see 3.1) must trip current, and frequency (if applicable).
- c Apply specified (see 3.1) input conditions for a time equal to or greater than the specified (see 3.1) must trip time.
- d Verify that the solid state relay shuts OFF within the specified (see 3.1) time by measuring the output current I(output), or the output voltage V(output).
- Verify that the solid state relay meets the trip characteristics at the various current levels specified (see 3.1).

### 4 7 7 5 Turn-on into a shorted load (see 3 12.11).

- a. Test set up per figure 1.
- b. Apply specified (see 3.1) voltage, and frequency (if applicable)
- c. Close switch S1
- d Apply specified (see 3.1) input conditions to turn the solid state relay on
- e Verify that the solid state relay shuts OFF by measuring the output current I(output).
- f Reset solid state relay, then repeat twice

### 4 7.7.6 Shorted load with solid state relay ON (see 3 12.12).

- a. Test set up per figure 1
- Apply the specified (see 3.1) load, voltage, and frequency (if applicable).
- c. Apply specified (see 3.1) input conditions to turn the solid state relay on.
- d Close switch S1.
- e Verify the solid state relay shuts OFF by measuring the output current I(output)
- f. Reset solid state relay, then repeat twice

### 4.7.7.7 Status turn-on time (see 3 12.13)

- a Test set up per figure 1.
- b. Apply specified (see 3 1) load, voltage, and frequency (if applicable).
- c Apply specified (see 3.1) input conditions, and activate the necessary status conditions to turn the status output ON.
- d. Verify that the status turn-on time is within specification (see 3.1)

# 4.7.7.8 Status "ON" voltage (see 3 12.14).

- a. Test set up per figure 1
- b Apply specified (see 3.1) load, voltage, and frequency (if applicable)
- c Apply specified (see 3.1) input conditions, and activate the necessary status conditions to turn the status output ON.
- d Verify that the status current I(status) is within specification (see 3.1) and that the status "ON" voltage  $V_a$ (on) is within specification (see 3.1).

# 4 7.7 9 Status turn-off time (see 3.12 15)

- a. Test set up per figure 1
- b Apply specified (see 3 1) load, voltage, and frequency (if applicable).
- c Apply specified (see 3.1) input conditions, and activate the necessary status conditions to turn the status output OFF
- Verify that the status turn-off time is within specification (see 3.1)

# 4 7.7.10 Status "OFF" voltage (see 3 12 16)

- a Test set up per figure 1
- b Apply specified (see 3.1) load, voltage, and frequency (if applicable)
- c  $\,$  Apply specified (see 3.1) input conditions, and activate the necessary status conditions to turn the status output OFF
- d Verify that the status current I(status) is within specification (see 3.1) and that the status "OFF" voltage  $V_s(\text{off})$  is within specification (see 3.1)

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### 4 7.7.11 Status blocking voltage (see 3.12.17).

- a. Test set up per figure 1.
- b. Apply specified (see 3.1) load, voltage, and frequency (if applicable).
- c Apply specified (see 3.1) input conditions and necessary status turn off conditions.
- d Apply the specified (see 3.1) status blocking voltage, V(status).
- e Verify that the status current I(status) is within specification (see 3.1).

### 4.7 7.12 Status leakage current (see 3.12.18).

- a. Test set up per figure 1.
- b. Apply specified (see 3.1) load, voltage, and frequency (if applicable).
- c. Apply specified (see 3.1) input conditions and necessary status turn off conditions
- d. Apply the maximum specified (see 3.1) status voltage V(status),
- e. Verify that the status leakage current I(status) is within specification (see 3.1).

### 4.7.7 13 Turn-on time (see 3 12.19)

- a. Test set up per figure 1.
- b Apply the specified (see 3.1) load, voltage, and frequency (if applicable).
- c. Apply specified (see 3.1) input turn-on conditions
- d. Verify that the solid state relay turns ON in the specified (see 3.1) time by measuring the output voltage V(output).

# 4.7.7.14 Turn-off time (see 3.12 20)

- a. Test set up per figure 1
- b Apply the specified (see 3.1) load, voltage, and frequency (if applicable)
- c Apply specified (see 3.1) input turn—on conditions, then apply the specified (see 3.1) input turn—off conditions
- d Verify that the solid state relay turns OFF in the specified (see 3.1) time by measuring the output voltage V(output).

### 4 7 7 15 Output voltage drop (see 3.12.21).

- a Test set up per figure 1
- b Apply the specified (see 3.1) load, voltage, and frequency (if applicable).
- c Apply specified (see 3.1) input turn-on conditions
- d Verify that the voltage drop is within specification (see 3.1) by measuring V(output)

### 4.7.7.16 Output leakage current (see 3 12.22).

- a. Test set up per figure 1.
- b. Apply the specified (see 3 1) load, voltage, and frequency (if applicable).
- c. Apply the necessary input conditions to turn the output off.
- d. Verify Leakage current is within specification (see 3.1) by measuring I(output).

# 4 7.7 17 Transient voltage (see 3.12.23)

- a Test set up per figure 1.
- b. Apply the necessary input conditions to turn the output off. .
- c Apply the specified (see 3.1) voltage, and frequency (if applicable), and test load.
- d. For the specified (see 3.1) time apply the specified (see 3.1) transient voltage to the output of the solid state relay. For the purpose of test, a low current supply may be used
- e. Monitor the output to verify that the solid state relay does not turn on.

### 4 7 7 18 DC offset voltage (AC solid state relays only) (see 3 12.24)

- a Test set up per figure 2
- b Apply the specified (see 3.1) load, voltage, and frequency
- c Apply specified (see 3.1) input turn-on conditions
- d. Verify the offset voltage is within specification (see 3.1) by measuring V(offset)

# 4 7.7 19 Waveform distortion (AC solid state relays only) (see 3.12 25)

- a Test set up per figure 1
- b. Apply specified (see 3.1) load, voltage and frequency
- c. Apply specified (see 3.1) input turn-on conditions.
- d With solid state relay turned ON, verify that output voltage, V(output), is within specification (see 3.1) (see figure 3)

### 4 7 7.20 Minimum load current rating (AC solid state relays only) (see 3.12.26)

- a Test set up per figure 1
- b. Apply specified (see 3.1) voltage and frequency, and minimum specified (see 3.1) load current
- c Apply specified (see 3.1) input turn-on conditions
- d Verify that the solid state relay turns ON and remains ON by measuring the output voltage, V(output)

### 4.7.7.21 Exponential rate of voltage rise (dv/dt) (see 3.12.27).

- a. Test set up per figure 4, or equivalent as approved by the qualifying activity.
- b. Apply zero bias voltage (if applicable) and zero control voltage.
- c. Connect the output terminals of the solid state relay under test to the circuit of figure 4.
- d Close and open S1 for a minimum of 10 times. After 5 cycles, reverse the polarity to the solid state relay (AC solid state relays only). Verify that the solid state relay achieves the specified (see 3.1) output voltage within the specified (see 3.1) time by measuring V(output).

### 4 7.7.22 Zero Crossing (AC solid state relays only) (see 3.12.28).

- a Test set up per figure 1.
- b. Apply specified (see 3.1) load, voltage and frequency.
- c. Apply specified (see 3.1) input turn-on conditions.
- d Apply the input turn—on condition at 90°(±10°) and 270° (±10°) of the load supply voltage and monitor the output voltage waveform, V(output) for the moment of turn on. The maximum value of "zero" voltage turn—on shall be as specified (see 3.1).
- e. Apply the input turn-off condition at 90°(±10°) and 270° (±10°) of the load supply voltage and monitor the output current waveform, I(output), for the moment of turn off. The solid state relay shall not turn off with the removal of input conditions until the AC load current is below the specified (see 3.1) value

# 4.7.7.23 Electrical system spike, 25°C only. (see 3.12.29) (for qualification and periodic inspections only).

- a. Test set up per figure 5.
- b With switch S3 open and S2 closed, cycle switch S1 and observe oscilloscope CH1 (or other equivalent instrument). Adjust V1 to obtain a minimum spike amplitude of 600 volts.
- c. Close switch S3 and cycle switch S1 at 10 +/- 1 pulses per second for the specified (see 3.1) time.
- d. Reverse the polarity of V1 and repeat (b) and (c)
- e. After completion, the solid state relay shall be tested for output leakage current (4.7.7 16), turn on time (4 7 7 13), and turn off time (4 7.7 14).

#### 4.7 7.24 Overload, 25°C only (see 3 12.30) (for qualification and periodic inspections only).

- a Test set up per figure 1
- b Apply the specified (see 3.1) overload conditions. Unless otherwise specified (see 3.1), the load shall be 3.5 times the specified (see 3.1) current at specified (see 3.1) voltage.
- c. Apply specified (see 3.1) input turn-on conditions
- d The solid state relays shall be cycled on and off 10 times. The period shall be 1 second and the duty cycle shall be 10 percent, unless otherwise specified (see 3.1)
- e After completion, the solid state relay shall be tested for output leakage current (4.7 7 16), and turn-on voltage in accordance with 4.7 7 2 2 or 4 7 7 2 6 as applicable

- 4.7 7.25 <u>Electromagnetic interference, 25°C only. (see 3.12.31) (for qualification and periodic inspections only)</u> Solid state relays shall be subjected to electromagnetic interference as specified (see 3.1) in MIL-STD-461, part 2, and MIL-STD-462, method CEO3. Maximum broadband conducted emission on power lines, with a resistive load at maximum output voltage and current, during steady state and switching conditions, shall be within specifications (see 3.1).
  - 4 7 7.26 Power dissipation, 25°C only. (see 3.12.32) (for qualification and periodic inspections only).

### A. ON state

- 1 Test set up per figure 1
- 2 Apply the maximum load, voltage, and specified frequency (if applicable).
- 3 Apply specified (see 3.1) maximum input turn-on conditions.
- 4 Measure all currents and corresponding voltages and calculate the product of each. Calculate the power dissipation by adding each product with the output voltage drop times output current, for each output switch in addition to any power dissipated by internal power supplies.
- 5. Verify that the total power dissipation does not exceed the specified (see 3.1) limits.

### B OFF state

- 1. Test set up per figure 1.
- 2. Apply the maximum load, voltage, and specified frequency (if applicable).
- 3 Apply specified (see 3.1) maximum input turn-off conditions.
- 4. Measure all currents and corresponding voltages and calculate the product of each. Calculate the power dissipation by adding each product with the output voltage drop times output current, for each output switch in addition to any power dissipated by internal power supplies.
- 5. Verify that the total power dissipation does not exceed the specified (see 3.1) limits.
- 4 7 8 Resistance to solvents (see 3 13) Solid state relays shall be tested in accordance with method 215 of MIL-STD-202 or method 2015 of MIL-STD-883. The following details and exceptions shall apply.
  - a. Portion to be brushed: All marking.
  - b Specimens to be tested. One specimen each for the four solutions.
  - c. Examination: Specimens shall be examined for legibility of marking
- 4 7.9 <u>Shock (specified pulse) (see 3 14)</u> Solid state relays shall be tested in accordance with method 213 of MIL-STD-202. The following details and exceptions shall apply:
  - a. Hounting method. As specified in 4.7.10b.
  - b Test condition: F.
  - c Electrical-load conditions. In each direction of shock, the solid state relay shall be deenergized during two shocks and energized by applying rated input voltage, rated load voltage (and frequency) and load, during one shock.
  - d. Measurements and examinations after shock. As specified in 4 7.10e

- 4.7 10 <u>Vibration (see 3.15)</u>. Solid state relays shall be tested in accordance with method 204 of MIL-STD-202. The following details and exceptions shall apply:
  - a Tests and measurements prior to vibration. None.
  - b. Method of mounting: Rigidly mounted by normal mounting means. Solid state relays designed for printed-circuit (PC) board application shall be soldered by normal means to a printed-circuit board of any convenient size, which shall in turn be secured by screws to a suitable fixture.
  - c. Test condition: F, except 100g peak.
  - d. Fifty percent of the time, in each of the three mutually perpendicular planes, the solid state relay shall be energized by applying input voltage with a 50% duty cycle, rated load voltage (and frequency) and load, and be deenergized for the remaining 50 percent.
  - e. Measurements and examination: Solid state relays shall then be examined for Evidence of breaking, cracking, chipping or flaking of the finish, or loosening of the terminals.
- 4.7.11 <u>Terminal strength (see 3.16)</u>. Solid state relays shall be tested in accordance with method 211 of MIL-STD-202 in accordance with the following, as applicable. Unless otherwise specified herein, two terminals of each discrete design, size, and configuration shall be tested; however, if there is only one terminal of such design, size, and configuration, it shall be tested.
- 4.7 11.1 Pull test (all terminal types) Terminals shall be tested as specified in method 211, test condition A of MIL-STD-202. The force shall be as specified (see 3.1).
- 4.7.11.2 Bend test (not applicable to plug-in terminals). Terminals shall be tested as specified in method 211, test condition B (two bends) or C of MIL-STD-202, as applicable. Loads for test condition C shall be as specified (see 3.1)
- 4.7.11.3 Twist test (wire lead terminals only) All terminals shall be tested as specified in method 211, test condition D of MIL-STD-202, except during application of torsion, each terminal shall be rotated 45 degrees in one direction, then returned to start; rotated in opposite direction 45 degrees, then returned to start. Each terminal shall be subjected to two such rotations and returns. Each terminal shall be held at a point 0.25 inch from the point of emergence from the solid state relay and in one plane shall be bent 20 ±5 degrees in one direction, then returned to start; rotated in opposite direction 20 ±5 degrees, then returned to start. This procedure shall then be repeated in the perpendicular plane. Following these tests, solid state relays shall be examined for evidence of loosening or breaking of the terminals and other damage that could adversely affect the normal operation of the solid state relay.
- 4.7.12 Moisture resistance (applicable to nonhermetically sealed solid state relays only) (see 3.17). Solid state relays shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:
  - a. Mounting: On a corrosion-resistant panel by normal mounting means.
  - b. Initial measurement Not applicable.
  - c Polarization During steps 1 through 6, 100 volts shall be applied between the input (positive) and the case, frame, or enclosure (negative), as applicable on one half of the sample solid state relays. No polarization voltage shall be applied to the other half of the sample solid state relays.
  - d. Final measurements Upon completion of step 6 of the final cycle, insulation resistance shall be measured as specified in 4.7.5. After a 24-hour drying period at a relative humidity of 50 ±5 percent, dielectric withstanding voltage shall be measured as specified in 4.7.6, except the test voltage shall be 90 percent of initial potential.
  - e Examination after test. Solid state relays shall be examined for evidence of breaking, cracking, chipping or flaking of the finish, or loosening of the terminals.

4 7.13 <u>Crosstatk (when specified) (see 3.18)</u>. Crosstalk shall be measured using equipment which shall have an input impedance of 1 megohm, minimum, and shall be paralleled with a capacitance of 20 picofareds maximum. A 1.0 to 10.0 volts peak-to-peak input signal at frequencies up to 10 megahertz shall be applied to the switching circuit through coaxial cable, terminated in 50 ohms ±5 percent at the solid state relay terminal. The coaxial cable shall conform to MIL-C-17. The input signal amplitude shall be measured at the terminals of the solid state relay. The terminals where crosstalk is to be detected shall be connected through a similar type coaxial cable, terminated in 50 ohms 5 percent at the measuring solid state relay. The resultant attenuation, in decibels (dB), equals:

- 4.7.14 <u>Isolation (when specified) (see 3.19)</u>. The capacitance shall be measured using method 305 of MIL-STD-202. The following details apply:
  - a Test frequency: 1 kilohertz (kHz).
  - b. Points of measurement: Between all isolated terminals.
- 4.7.15 Resistance to soldering heat (when specified) (see 3.20). Solid state relays shall be tested in accordance with method 210 of MIL-STD-202. The following details and exceptions shall apply:
  - a Depth of immersion in molten solder: Within .060 ±.020 inch of the solid state relay base.
  - b Test condition: G.
  - c. Measurements after test: Insulation resistance and dielectric withstanding voltage as specified in 4.7.5 and 4.7.6.
  - d. Examination after test As specified in 4.7 10e
- 4.7.16 <u>Salt spray (corrosion) (see 3.21)</u>. Solid state relays shall be tested as specified in 4.7.16.1 or, when specified (see 3.1), in accordance with 4.7.16.2.
- 4.7.16.1 <u>Sait spray</u>. Solid state relays shall be tested in accordance with method 101 of MIL-STD-202. The following details and exceptions shall apply:
  - a. Applicable salt solution: 5 percent.
  - b. Test condition: B
  - c Examination after test. Solid state relays shall be examined for evidence of peeling, chipping or blistering of the finish, and exposure of base metal due to corrosion
- 4.7.16.2 <u>Salt atmosphere (corrosion), (when specified, see 3.1)</u> Solid state relays shall be tested in accordance with method 1041 of MIL-STD-750. Examination after test shall be as specified in 4.7.16.1c

- 4.7 17 <u>Life (see 3.22)</u>. Solid state relays shall be subjected to the following procedures:
  - a. With the solid state relays mounted in accordance with 4.7.10b, they shall be operated for 48 hours in accordance with 4.7.2.6, except the duration of the turn on shall be 50 ±5 percent of each operation of the solid state relay. The ambient temperature of the solid state relay environment shall be maintained at the highest specified operating temperature (see 3.1). Repeat as above for 48 hours, except with the ambient temperature at the lowest specified operating temperature Repeat as above for 48 hours, except with the temperature at room ambient.
  - b. Same as a, except with the maximum turn-off voltage continuously applied to the input. Solid state relays shall be monitored to verify that they remain turned off.
  - c. Same as b above, except with the minimum turn—on voltage continuously applied to the input. Solid state relays shall be monitored to verify that they remain turned on.
  - d. The transient voltage test shall then be performed as specified in 4.7.7.17.
  - e. Repeat steps a through d above for each additional load specified.
  - f. After the above tests, solid state relays shall be subjected to the insulation resistance, dielectric withstanding voltage, and the electrical characteristics (see 4.7.5, 4.7.6, and 4.7.7.1 through 4.7.11).

#### 5. PACKAGING

- 5.1 <u>Physical protection</u>. Solid state relays shall be packaged in a manner that will ensure compliance with the applicable requirements of MIL-P-116, method III, except for those solid state relays classified as electrostatic discharge sensitive (ESDS).
- 5.1.1 <u>Wrapping and cushioning and lead protection for ESDS solid state relays</u>. Leads and terminals shall be protected by container design, die-cut inserts, vials, or suitable noncorrosive supporting materials or solid state relays to prevent damage to the item or packaging. Leads or terminals shall extend outward and be maintained in a configuration as manufactured without causing undue loads or stresses capable of causing damage to the solid state relays. Materials used to maintain item position and lead configuration shall permit item removal and replacement without bending the leads. All solid state relays shall be wrapped or cushioned with noncorrosive materials which shall not crumble, flake, power or shed. Non-static generating materials shall be used for solid state relays susceptible to environmental field force damage. For these susceptible solid state relays, materials conforming to type II of MIL-B-81705 or small bags conforming to MIL-B-117, type I, class A, style 2 shall be used as wraps or small pouches respectively. Alternatively, cushioning materials conforming to PPP-C-795, class 2; PPP-C-1752, type VII, class 4, PPP-C-1797, type II; or PPP-C-1842, type III may be used. Any materials used shall be in accordance with MIL-STD-2073-2, table IV for wrapping materials and table V for cushioning materials.
- 5.1.2 Electrostatic and electromagnetic shielding and corrosion protection. Electrostatic and electromagnetic (as well as protection from corrosion, contamination, and thermal shock) shall be provided by placing the wrapped or cushioned solid state relays in heat sealed bags or envelopes fabricated with material conforming to MIL-B-117, type I, class F, style 1. To avoid capacitor effects, each bag or envelope shall be fabricated from one continuous piece of barrier material. For immediate use applications and for those instances where no exposure to electrostatic or electromagnetic fields are anticipated, barrier material conforming to type II of MIL-B-81705 may be used to meet level C protection requirements.
  - 5.2 Preservation Preservation shall be level A or C, as specified (see 6.2)
  - 5.2 1 Level A
- 5.2 1.1 <u>Cleaning</u> Solid state relays shall be clean or be cleaned in accordance with MIL-P-116, process c-1
  - 5.2 1.2 Drying Solid state relays shall be dry or be dried in accordance with MIL-P-116.
  - 5 2 1 3 Preservative application Preservatives shall not be used

- 5.2.1.4 <u>Unit packs</u> Each solid state relay shall be individually unit packed in accordance with method III of MIL-P-116 specified herein insuring compliance with the applicable requirements of that specification.
- 5.2.1.4.1 <u>Hermetically sealed solid state relays</u>. Hermetically sealed solid state relays shall be unit packed in accordance with method III.
- 5.2.1.4.2 <u>Nonhermetically sealed solid state relays</u>. Nonhermetically sealed solid state relays shall be unit packed in accordance with submethod IA-15.
- 5.2.1.5 <u>Intermediate packs</u>. The intermediate container shall be as specified in the "Intermediate pack requirements" of MIL-STD-2073-1.
- 5.2.2 <u>Level C</u>. The level C preservation for solid state relays shall conform to the MIL-STD-2073-1 requirements for this level.
  - 5.3 Packing. Packing shall be level A, B, or C, as specified (see 6.2).
- 5.3.1 <u>Level A</u>. The packaged solid state relays shall be packed in wood boxes conforming to PPP-8-601, overseas type or PPP-8-621, class 2. Closure and strapping shall be in accordance with the applicable container specification, except that metal strapping shall conform to ASTM D 3953. The requirements for level B packing shall be used when the total quantity of a stock numbered solid state relay for a single destination does not exceed a packed volume of one cubic foot (0 02832 cubic meter).
- 5.3.2 <u>Level B</u>. The packaged solid state relays shall be packed in fiberboard containers conforming to PPP-B-636, class weather resistant, style optional, special requirements. The requirements for box closure, waterproofing and reinforcing shall be in accordance with method V of the PPP-B-636 appendix.
- 5.3.3 <u>Level C</u>. The level C packing for solid state relays shall conform to the MIL-STD-2073-1 requirements for this level.

## 5.4 Marking.

- 5.4.1 <u>Standard marking</u>. In addition to any special or other identification marking required by the contract (see 6.2), each unit, supplementary, intermediate, and exterior container and unitized load shall be marked in accordance with MIL-STD-129. The complete military or contractors' type or part number (PIN), as applicable, including the Commercial and Government Entity (CAGE) code, shall be marked on all unit and intermediate packs in accordance with the identification marking provisions of MIL-STD-129. When specified in the contract (see 6.2), the marking of domestic shipments for civil agencies shall be in accordance with FED-STD-123.
- 5.4.2 <u>Bar code marking</u> Bar code markings are required and shall be applied in accordance with MIL-STD-129 and MIL-STD-1189
  - 5.5 General.
- 5.5.1 <u>Exterior containers</u>. Exterior containers (see 5 3.1, 5.3.2, and 5.3.3) shall be of a minimum tare and cube consistent with the protection required and shall contain equal quantities of identical stock numbered items to the greatest extent practicable
  - 5 5 2 Packaging inspection Packaging inspection requirements shall be in accordance with 4.6.3
  - 6 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 <u>Intended use</u>. Solid state relays conforming to this specification are intended for use in aircraft, missiles, spacecraft and ground support electronic and communication equipment as a means of controlling the circuits of electrically operated equipment and solid state relays. Consult MIL-STD-1346 as to selection and application. For telegraph solid state relays, see MIL-R-27777, "Relays, Telegraph, Passive, Solid State, General Specification for". This specification is not intended to cover photosensitive relays.

NOTE: Users are cautioned to ensure that temperature limitations, transient voltages and momentary current overloads do not exceed the applicable parameters of a solid state relay proposed for a specific application. During high voltage testing, due caution should be exercised to avoid damage. Polarity, when applicable, should be observed. Due to the use of nonlinear-response assembly parts and the inherent difference between electromechanical and solid state relays, impedance values are not necessarily similar between corresponding terminals of solid state relays of the two types with like ratings.

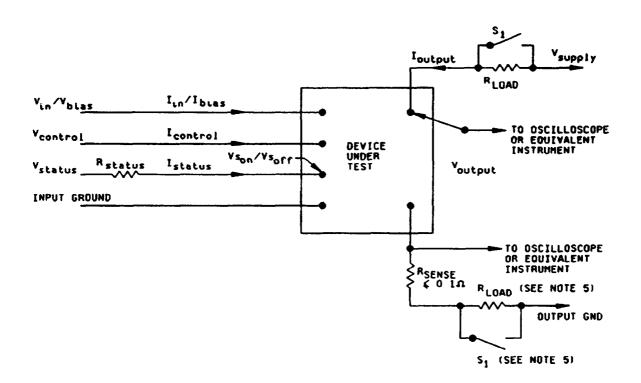
- 6.2 Ordering data. Acquisition documents should specify the following:
  - a. Title, number, and date of this specification.
  - b. Title, number, and date of the applicable specification sheet, and the military part number.
  - c. Levels of preservation and packing required (see 5.1 and 5.2).
  - d. If special or additional identification marking is required (see 5.3).
- 6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in applicable Qualified Products List (QPL) whether or not such products have actually been so listed by that date. The attention of the manufacturers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Space and Naval Warfare Systems Command, ATTN: SPAWAR 8111, Department of the Navy, Washington, DC 20363; however, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-EQP), 1507 Wilmington Pike, Dayton, Ohio 45444. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.3.1).
- 6.3 1 Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.
- 6.4 <u>Definitions</u> The definitions listed below are not a complete glossary of solid state relay terminology, but rather are intended as definitions of the technical terms as applied within this specification.
- 6.4.1 <u>Input</u> The circuitry within a solid state relay which responds to input voltage and causes the solid state relay to turn on
- 6.4 2 <u>Output</u> The circuit within a solid state relay which changes from conducting to nonconducting state and vice-versa.
- 6 4.3 <u>Time, turn-off</u>. The interval between the removal of input voltage and the output reaching 90 percent of its ultimate change in voltage when the solid state relay is turned off
- 6 4 4 <u>Turn-on</u> The change in solid state relay condition (caused by the input voltage exceeding a predetermined minimum turn-on voltage) resulting in the output changing from a nonconducting to a conducting state (or vice-versa).
- 6.4.5 <u>Time, turn-on</u> The interval between the application of input voltage and the output reaching 90 percent of its ultimate change in voltage when the solid state relay is turned on.
- 6 4 6 <u>Solid state relay</u> A static relay or relay unit constructed exclusively of solid state components See MIL-R-28776 for hybrid relays

- 6 4.6.1 Short circuit protected solid state relay. A solid state relay with circuit breaker type action that protects the solid state relay from overload, shorted load or over-temperature conditions.
- 6 4.6 2 Status. An auxiliary, low-current switch segment of the solid state relay that indicates the condition of the solid state relay itself. Examples of status are switch status (main switch open or closed); trip status (main switch turned off due to overcurrent), flow status (minimum output current flowing); and B.I.T (built-in-test).
- 6 4.7 <u>DC offset voltage</u> AC solid state relays use semiconductors which switch each half cycle of the supply voltage independently. Consequently, a DC component of voltage can be developed as a result of unsymmetrical switching and unbalance in voltage drop across each semiconductor switch. This is detrimental to loads such as transformers if the DC component of voltage is excessive.
- 6.4.8 <u>Waveform distortion</u>. Improper SCR gating circuit design can result in deviation from the fundamental sinusoidal current or voltage waveform
- 6.4.9 <u>Current rating (AC solid state relays only)</u> Improper SCR gating circuit design will require typically 100 milliamperes of load demand for proper SCR firing and conduction. Solid state relay should be designed to operate properly independent of load demand. All commercially available solid state relays require approximately 100 milliamperes of load current to reduce DC offset and distortion to acceptable levels.
- 6.4.10 Bias current The bias current is required in solid state relays with single or multiple double throw outputs to energize the normally closed switches when this current is not obtained from the load side of the solid state relay. A bias current is also required in special solid state relay designs such as an electronic latching relay.
- 6 4.11 Reverse polarity protection (DC operated solid state relays only). An input circuit that prevents damage to the solid state relay, limits the input current and prevents solid state relay turn-on when the input terminals are inadvertently reversed.
- 6.4.12 Zero crossover (AC solid state relays only). A desirable characteristic in solid state solid state relays that switch AC voltages. This characteristic is designed into the solid state relay to force it to turn on only near zero voltage and to turn off near zero load current in the AC voltage and current cycles when connected in series with the load regardless of when the input voltage is applied or removed. This design feature is beneficial in extending solid state relay life while reducing radiated EMI
- 6 4.13 <u>Heat sink</u>. A heat sink is a device to which the solid state relay is attached for the purpose of conducting, absorbing, and radiating heat away from the solid state relay so that its case temperature is not exceeded. Heat sinks may also be attached to high power dissipating devices within the solid state relay to aid in the transfer of heat from the device to the case of the solid state relay.
- 6 4 14 <u>Assured turn-on voltage</u> The assured turn-on voltage is the minimum value of the input voltage at which the solid state relay is guaranteed to turn on.
- 6 4 15 <u>Assured turn-off voltage</u>. The assured turn-off voltage is the maximum value of the input voltage at which the solid state relay is guaranteed to be off
- 6 4 16 <u>Input configuration</u>. Input configuration requires only one voltage (or current) applied at the input terminals. This input voltage determines the state of the output of the solid state relay.
- 6 4.17 <u>Control configuration</u>. Control configuration requires a bias voltage present, and a separate 'control' input. This 'control' input determines the state of the output of the solid state relay.
- 6 4 18 <u>Blas voltage</u> Blas voltage is a voltage present at the input of the solid state relay at all times. This voltage provides steady state current to the electronics in the input circuit of the solid state relay. The blas voltage does not control the state of the output of the solid state relay. See "Control configuration"
- 6.4.19 Trip Curve The trip curve sets the minimum and maximum trip points of the solid state relay and is plotted as current versus time, typically an inverse  $I^2$ t relationship

- 6.4.20 <u>Load Current</u>. Load current is the intended maximum current the solid state relay is capable of carrying for an indefinite amount of time
  - 6 4 21 Trip. The automatic interruption of current which results from electrical overloads.
- 6 4.22 Reset The restoration of the tripped solid state relay to a state from which it can be turned on.
- 6.5 <u>Application information</u>. Solid state relays (SSR's) enjoy the advantages of sensitivity, bounce—free contact action, and indefinitely long life in environments which do not exceed the voltage or temperature rating.
- 6.5.1 <u>Solid state relay/mounting surface interface</u>. The interface between the solid state relay and its mounting surface should be given special attention because most of the heat generated within the solid state relay must pass through this interface. To insure that this interface passes as much heat energy as possible, while remaining relatively cool, the thermal resistance (°C rise per watt dissipated within the solid state relay) between the solid state relay case and the mounting surface (especially for load currents over 1.0 ampere) should be kept as low as possible.
- 6.6 <u>Sealing (degassing)</u>. The following procedure is suggested as a guide; however, every effort should be made to utilize the most effective procedure consistent with the state of the art.
  - a. Evacuate to less than 200 micrometers.
  - b Heat to maximum rated ambient temperature with continued evacuation (see 3.1)
  - c. Maintain heat and vacuum for 12 hours or longer, continuing the treatment until a maximum pressure of 80 micrometers is reached.
  - d. Turn off heaters and maintain pressure for four hours.
  - e. Close evacuation valve and fill chamber with the desired inert pressurizing gas.
  - f Seal solid state relay before removing from chamber
  - 6.7 Subject term (key word) listing.

Bias input configuration Control input configuration Hybrid Marking Relay, solid state Screening Short circuit protection

- 6.8 <u>Supersession data</u> Screening levels 'X' and 'W', that previously appeared in MIL-R-28750, no longer exist and should be superseded by the 'Y' screening level
- 6.9 <u>Changes from previous issue</u> Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes



## NOTES

- $R_{\sf SENSE}$  may be replaced by an isolated current probe (current transformers, hall effect devices, or equivalent)
- 2 Status terminals as applicable
- 3
- V<sub>STATUS</sub> and R<sub>STATUS</sub> as applicable Unless otherwise specified, resistive loads are used for testing methods 4
- 5. Option load may be connected as shown

FIGURE 1 General test setup

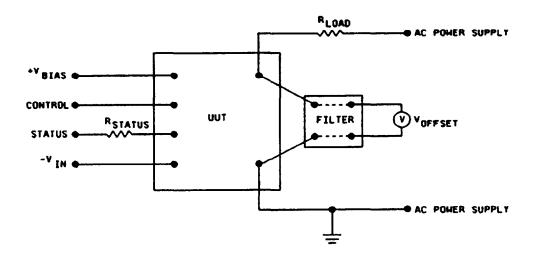
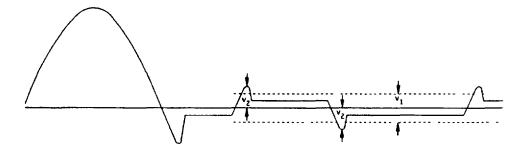


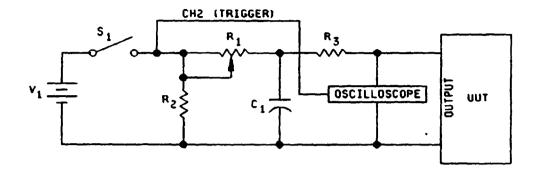
FIGURE 2 DC offset voltage setup



V1 - MAVEFORM DISTORTION VOLTAGE (RMS)

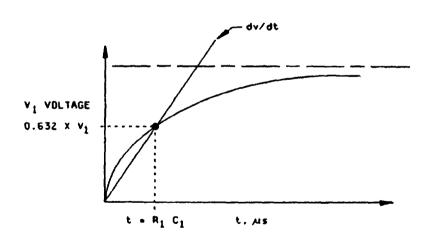
V2 = MAVEFORM DISTORTION VOLTAGE (PEAK)

FIGURE 3. Waveform distortion.



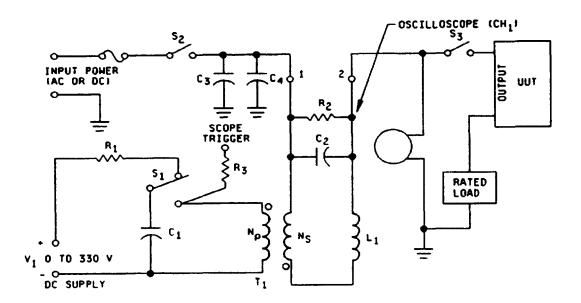
 $V_1$  = Maximum rated output voltage (ac devices use  $V_1$  =  $V_{RATED}$  (RMS) x 1.414)  $R_1$  = See equation below.  $R_2$  = 1.0 megohm (±5 percent), 1/2 watt  $R_3$  = 50 ohm (±5 percent)  $C_1$  = 0.01  $\mu$ F (±5 percent).  $C_1$  = 10 amp Hg wetted switch (or equivalent).

## DV/DT test setup



DV/DT curve

FIGURE 4. DV/DT



## NOTES

- A mechanically or electronically operated switch may be used to replace S1 1
- The transformer windings should be bi-filler 2
- A 50 ohm resistor replaces the equipment under test for verifying the source impedance 3
- Component values are as follows
  - c1 = 2 microfarads, 1500 volts
  - C2 = 0 03 microfarads, 2000 volts C3 = 10 microfarads, 1000 volts
  - C4 = 0 01 microfarads, 1000 volts R1 and R2 = 100 ohms, 1 watt

  - R3 = 1 megohm, 0.5 watt
- \$1, \$2, and \$3 = 20 amp, SPDT switch
- L1 = 50 turns, 2 inch diameter/
  - #16 AWG
- T1 = Air core transformer, 2 inch
  - diameter/#16 AWG,
  - Np = 20 turns, Ns = 60 turns

FIGURE 5 Electrical system spike test setup

#### REQUIREMENTS FOR HYBRID MICROCIRCUIT ELEMENTS

#### 10 SCOPE

- 10.1 <u>Statement of scope</u>. This appendix establishes the procedures for the testing of the elements used in the construction of Class II solid state relays to assist in achieving a level of quality and reliability commensurate with the intended application. It shall be used in conjunction with other documentation such as MIL-STD-883, the solid state relay specification sheet (see 3.2) and an applicable element detail specification to establish the design, material, performance, control, and documentation requirements which are needed to achieve prescribed levels of quality and reliability. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.
  - 20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

#### 30. Procedure.

30.1 <u>Solid state relay element evaluation requirements</u> or multichip microcircuit and hybrid/integrated circuits. Four phases of solid state relay element evaluation are required (see table I).

Requirement	Reference Paragraph	Table
Microcircuit and semiconductor dice	30.2.2	11
Passive elements	30 2.3	111
Ceramic substrate printed wiring	30.2 4	IV
Process control	30.3	V

TABLE I. Solid state relay element evaluation summary.

- 30.1.1 <u>Precedence</u>. Unless otherwise specified in the specification sheet, the test requirements and conditions shall be as given herein.
- 30.1.2 <u>Sequence of testing</u> Subgroups within a group (table) of tests may be performed in any sequence, but individual testing within a subgroup shall be performed in the sequence indicated.
- 30 1 4 <u>Protection from electrostatic discharge</u>. For elements and solid state relays that are sensitive to electrostatic discharge, suitable handling precautions and grounding procedures shall be taken to protect the elements and solid state relays from accidental damage.

## 30.2 Element evaluation.

## 30.2.1 General.

- 30 2.1.1 <u>Element</u> Herein, "element" refers to materials for solid state relay assembly. Before solid state relay assembly, element characteristics shall be evaluated to assure their compatibility with solid state relay requirements and assembly procedures (see table I).
- 30 2 1.2 <u>Characteristics</u> Characteristics to be verified shall be those necessary for compatibility with the element specification and assembly procedures, and at least those which cannot be verified after assembly but could cause functional failure of the solid state relay
- 30 2 1 3 <u>Location of element evaluation</u> Element evaluation may be performed at either the element supplier or solid state relay manufacturing facility

- 30.2.2 Evaluation of microcircuit and semiconductor dice.
- 30.2.2.1 <u>Electrical test specifications</u> Electrical test parameter, values, limits (including deltas), and conditions shall be as specified in the microcircuit or semiconductor dice detail specification.
- 30.2.2.2 <u>Evaluation of die</u>. At the option of the menufacturer and the approval of the qualifying activity of this specification, the evaluations of 30.2.2.2.1 and 30.2.2.2.2 are not necessary provided the dice used in the solid state relay assembly are JANC discrete semiconductors which have been tested in accordance with MIL-S-19500, Appendix H.
- 30.2.2.2 1 <u>Electrical testing of die</u>. Each die shall be electrically tested, which may be done at the wafer level provided all failures are identified and removed from the lot when the dice are separated from the wafer. The minimum requirements shall include static testing at 25°C (see MIL-H-38510 group A, subgroup 1 for microcircuits and MIL-S-19500 group A for semiconductors).
- 30.2 2.2.2 <u>Visual inspection of die</u>. Each die shall be visually inspected to assure conformance with the applicable die related requirements of MIL-STD-883, method 2010; MIL-STD-750, method 2072 and 2073; and the die specification.
- 30.2.2.3 <u>Evaluation of assembled die</u>. From each wafer lot, a sample shall be evaluated in accordance with table II and 30.2.2.3.1 through 30.2.2.3.2 Each sample shall be assembled into suitable packages that simulate the assembly methods and functional conditions of the element within the intended application
  - 30.2.2.3.1 Subgroup 1 and subgroup 2.
  - 30.2.2.3.1.1 Sample size The sample size shall be at least 10 dice from each wafer lot.
- 30.2.2.3.1.2 <u>Internal visual</u> Internal visual inspection shall be performed to assure conformance with the applicable die related requirements of MIL-STD-883, method 2010, MIL-STD-750, method 2072 and 2073, and the element specification.
- 30.2.2.3.1.3 Final electrical. Final electrical testing shall include static tests at 25°C, at maximum rated operating temperature, and at minimum rated operating temperature.
  - 30.2.2.3 2 Subgroup 3
- 30.2 2 3.2.1 <u>Sample size</u> From each wafer lot, a sample of at least 5 die requiring 10 bond wires minimum shall be selected.
  - 30.2.2.3.2.2 Wire bond strength testing. For wire bond strength testing.
    - a A minimum of ten wires, consisting of chip to package bonds shall be destructively pull tested. An equal number of bonds shall be tested on each sample die
    - b For beam lead and flip-chips, five dice shall be tested.
    - The die metallization shall be acceptable if no failure occurs. If only one wire bond fails, another sample shall be selected in accordance with 30 2 2 6 1 and subjected to subgroup 3 evaluation. If the second sample contains no failures, the bonding test results are acceptable if the second sample contains one or more failures, or if more than one failure occurs in the first sample, the lot of dice shall be rejected.
    - d The rejected wafer lot may be resubmitted to subgroup 3 evaluation if the failure was not due to defective die metallization

TABLE II. Assembled dice evaluation requirements.

Sub-  group	Test	MIL-STD-883			
		Method	Condition	Quantity (accept no.)	Reference paragraph
1	Internal visual	2010 2072, 2073 <u>1</u> /		10 (0)	30.2.2.3.1.2
2	Final electrical			10 (0)	30.2.2.3.1.3
3	Wire bond evaluation	2011		10(0) wires or 20(1) wires	30.2.2.3.2.2

1/ MIL-STD-750 methods.

## 30.2.3 Passive elements.

- 30.2.3.1 <u>Electrical test specifications</u>. Electrical test parameters, values, limits, and conditions shall be as specified in the passive element specification.
- 30.2.3.2 <u>Evaluation of passive element lots</u> At the option of the manufacturer and the approval of the qualifying activity of this specification, the evaluations of 30.2.3.2.1 and 30.2.3.2.2 are not necessary provided the passive elements used in the solid state relay assembly are procured from the established reliability (ER) series of military specifications (e.g., MIL-R-55342, MIL-C-55681); however, the passive elements must meet a minimum established failure rate level of P for screening level Y solid state relays. These established reliability elements must be JAN solid state relays and must be listed on the applicable opt
- 30.2.3.2.1 <u>Electrical testing of passive element lots</u> Each passive element shall be 100% electrically tested at 25°C, or as specified in the passive element specification.
- 30 2.3.2.2 <u>Visual inspection of passive elements lots</u>. Each passive element shall be 100% visually inspected to assure conformance with the applicable passive element specification and the related requirements of MIL-STD-883, method 2032.
- 30.2 3.3 <u>Evaluation of assembled passive elements</u> From each inspection lot of passive elements, a randomly selected sample shall be evaluated in accordance with table III and 30.2.3.3 1 through 30.2.3 3.3
  - a. Each sample shall be assembled into suitable packages when required to perform the applicable testing that simulate the assembly methods and functional conditions of the element within the intended application
  - b The sample shall contain at least 20 wire bonds (an equal number on each element) if the operation is applicable
- 30 2 3 3 1 <u>Visual inspection (subgroup 1)</u> Passive elements shall be visually inspected, using a sample of 22, to assure conformance with the applicable passive element specification and MIL-STD-883, method 2032

30.2.3.3.2 Electrical testing of passive elements (subgroup 2). Passive elements shall be electrically tested, using a sample of 10, at  $25^{\circ}$ C  $\pm$   $5^{\circ}$ C for the following characteristics (minimum)

- a Resistors: DC resistance.
- b Capacitors Ceramic type: Dielectric withstanding voltage, insulation resistance, capacitance, and dissipation factor.
- c Tantalum type: DC leakage current, capacitance, and dissipation factor.
- d. Inductors: DC resistance, inductance, and Q.

30.2.3.3.3 <u>Whire bond strength testing (subgroup 3)</u>. Whire bond strength testing applies to elements which are whire bonded during the solid state relay assembly operation. The sample shall include at least 5 elements and 10 bond whrea minimum.

- a. At least 10 wires, consisting of element to substrate and package bonds shall be destructively pull tested. An equal number of bonds shall be tested on each sample element
- b. The element metallization shall be acceptable if no failure occurs. If only one wire bond fails, a second sample shall be selected from the remaining elements in the evaluation sample, and subjected to the test per b, above. If the second sample contains no failures the bonding test results are acceptable. If the second sample contains one or more failures, or if more than one failure occurs in the first sample, the element lot shall be rejected.
- c. The element inspection lot may be resubmitted to evaluation if the failure was not due to defective element metallization.

Sub- group	Test	MIL-STD-883		0	
		Method	Condition	Quantity (accept no.)	Reference paragraph
1	Visual inspection	2032		22(0)	30.2.3.3 1
2	  Electrical			10(1)	30 2 3.3.2
3	    Wire bond evaluation	2011		10(0) wires or 20(1) wires	30.2.3 3.3

TABLE III. Assembled passive element evaluation requirements

## 30.2.4 Ceramic substrate printed wiring (substrates)

30 2 4 1 <u>Definition</u> For the purpose of substrate evaluation, a substrate inspection lot shall consist of homogeneous substrates having the same number of layers, manufactured using the same facilities, processes, materials, and vacuum deposited, plated or printed as one lot

- 30.2.4.2 <u>Electrical test specifications</u>. Electrical test parameters, values, limits and conditions shall be as specified in the applicable substrate detail specification.
  - 30.2.4.3 Evaluation of substrate element lots.
- 30.2.4.3.1 <u>Electrical testing</u>. Each substrate shall be electrically tested at 25°C, as specified in the applicable substrate detail specification.
- 30.2.4.3.2 <u>Visual inspection</u>. Each substrate shall be visually inspected to assure conformance with the applicable requirements of MIL-STD-883, method 2032, and the applicable substrate detail specification.
- 30.2.4.4 <u>Evaluation of assembled substrate elements</u>. From each inspection lot of substrates, a randomly selected sample shall be evaluated in accordance with table IV and 30.2.4.4.1 through 30.2.4.4.3. With preparing activity approval, destructive tests may be performed on test coupons which provide the required test data. The test coupons must be made with the same materials that were used in the manufacturing of the inspection lot and processed at the same time as the inspection lot.
  - 30.2 4 4.1 Subgroup 1. A minimum of five samples shall be submitted to subgroup 1 testing.
- 30 2.4 4.1.1 Physical dimension. Inspect in accordance with MIL-STD-883, method 2016 and the applicable substrate detail specification.
- 30.2 4.4 1.2 <u>Visual inspection</u>. Inspect in accordance with MIL-STD-883, method 2032 and the applicable substrate detail specification.

TABLE IV Assembled substrate evaluation requirements.

Subgroup	Test	MIL-STD-883		Quantity	Reference
		Method	Condition	(accept no.)	paragraph
1	Physical  dimension	2016		5 (O) 	30.2.4.4.1.1
	Visual   inspection	2032	<b>!</b> <b>!</b> !	†   	30.2.4.4.1.2
	Electrical	! <b> </b>		1	30.2 4 4 1.3
2	Conductor   thickness or   conductor   resistivity     Film adhesion			3 (0)	30.2 4.4.2.1  30.2 4.4.2.2   
3	Temperature  coefficient of  resistance			2 (O)   	30.2 4 4.3.1
	Wire bond evaluation	2011	   	10 wires (0)   30 wires (1)	30.2 4 4 3.2
	Die shear Levaluation	2019	<u> </u> 	2 (0)	30 2 4 4 3 3

- 30 2.4.4.1.3 <u>Electrical</u>. Substrates shall be electrically tested at 25°C for the following characteristics (minimum). Requirements shall be as specified in the applicable substrate detail specification
  - a Resistors DC resistance.
  - b Capacitors: Capacitance. If specified in the applicable substrate detail specification, test for dielectric withstanding voltage, insulation resistance, and dissipation factor
  - c. For multilayered substrates, continuity and isolation testing shall be performed to verify the interconnection of conductors as specified in the applicable substrate detail specification.
- 30.2.4.4.2 Subgroup 2 A minimum of three sumples that have been subjected to, and passed, subgroup 1 testing shall be submitted to subgroup 2 testing.
- 30.2.4.4.2.1 <u>Conductor thickness</u>. Measure conductor thickness in accordance with the applicable substrate detail specification. Conductor thickness shall meet the requirements specified in the applicable substrate detail specification.
- 30.2.4.4.2.2 <u>Conductor resistivity</u>. Ressure conductor resistivity in accordance with the applicable substrate detail specification. Conductor resistivity shall meet the requirements specified in the applicable substrate detail specification.
- 30 2.4.4.2.3 <u>Film adhesion</u>. Perform film adhesion testing per MIL-STD-977, method 4500. The substrate and tape shall show no evidence of peeling or flaking of metallization
- 30 2.4 4.2 4 <u>Solderability</u> For solderable substrates only, perform solderability testing if specified in the applicable substrate detail specification in accordance with the applicable substrate detail specification.
- 30.2 4.4.3 <u>Subgroup 3</u> A minimum of two samples that have been subjected to, and passed, subgroup 1 testing shall be submitted to subgroup 3 testing
- 30.2.4 4 3 1 <u>Temperature coefficient of resistance (TCR)</u>. When specified in the applicable detail specification, perform temperature coefficient of resistance (TCR) testing for resistors in accordance with MIL-STD-202, method 304. TCR shall meet the requirements specified in the applicable substrate detail specification
  - a. Thick film type. Test as a minimum, two resistors from each resistor paste sheet resistance value. One from the smallest and one from the largest area resistors at -55°C, and +125°C using a reference reading at +25°C, or temperatures as specified in the substrate detail specification.
  - b Thin film type: Test as a minimum, the highest value resistor at +125°C using a reference reading at +25°C or temperatures as specified in the substrate detail specification
  - c If specified in the applicable detail specification, TCR tracking testing shall be performed. TCR tracking shall meet the requirements specified in the applicable substrate detail specification.

- 30.2.4.4.3.2 Wire bond strength testing. For wire bondable substrates, perform wire bond strength testing in accordance with MIL-STD-883, method 2011. The sample shall include at least 2 substrates and 10 bond wires minimum.
  - a. At least 10 wires, consisting of substrate to substrate bonds, shall be destructively pull tested. An equal number of bonds shall be tested on each sample substrate.
  - b. The substrate metallization shall be acceptable if no failure occurs. If only one wire bond fails, a second sample of a minimum of 20 wires shall be prepared using the same wire type/size and the same type equipment as the failed bond. If the second sample contains one or more failures, or if more than one failure occurs in the first sample, then the substrate inspection lot shall be rejected.
  - c. The substrate inspection lot may be resubmitted to evaluation if the failure(s) was not due to defective substrate metallization.
- 30.2.4 4.3.3 <u>Die sheer strength testing</u>. Perform sheer strength testing in accordance with MIL-STD-883, method 2019. At least two die per substrate shall be attached and tested for each die attachment method, as specified in the applicable substrate detail specification. If a failure occurs at less than the specified force and is not due to defective substrate materials, the lot shall be resubmitted to die shear evaluation and the failure mode documented.
- 30.3 <u>Control of critical process and procedure (process control)</u> The indicated process shall be controlled in accordance with table V and 30.3.1.

		.,	
Constant	MIL-	Paragraph	
Operation	Hethod	Condition	raiagiapii
Wire bonding	2011 2023		30.3.1

TABLE V. Process control summary.

## 30.3 1 Wire bonding.

- 30.3 1 1 General. A process muchine/operator evaluation shall be performed:
  - a When a machine is put into operation.
  - b Periodically while in operation, not to exceed 4 hours.
  - c When the operator is changed.
  - d. When any machine part or an adjustment has been made
  - e. When the spool of wire is changed or a new solid state relay production lot is started.
- 30 3 1 2 <u>Test samples</u> Test samples that simulate the production solid state relay may be destructively evaluated in lieu of the product
  - 30.3 1 3 Process machines Process machines not meeting the evaluation requirements shall not be used
- 30.3 1.4 <u>Corrective action of process machine</u> A process machine may be returned to operation only after appropriate corrective action has been implemented and the machine has been evaluated and passed testing in accordance with table V as required

- 30.3 1.5 <u>Data record</u>. A data record shall be maintained and identifiable to each machine, operator, shift, and date of test.
  - 30 3 1.6 Wire bonding. Wire bond strength testing shall be performed as follows.
- 30 3 1 6 1 Process machine/operator evaluation A minimum sample of 10 wires total from 3 solid state relays shall be destructively pull tested in accordance with MIL-STD-883, method 2011.
  - a The sample shall consist of bonds to elements typical of solid state relay assembly operation.
  - b. Evaluation results are acceptable if no failure occurs below the present value given in table I of MIL-STD-883, method 2011. If any of the sample wires fail, the bonder shall be deactivated and corrective action taken. When a new sample has been prepared, tested, and passed this procedure, the machine/operator has been certified or recentified, it can be returned to production.
- 30.3.1.7 <u>Lot sample bond strength.</u> From each wire bonding lot, a sample of at least two solid state relays shall be nondestructively tested in accordance with MIL-STD-883, method 2023. Solid state relays with known visual wire bonding rejects shall not be excluded from this sample.
  - a. A wire bonding lot consist of solid state relays that are consecutively bonded using the same set-up and wire, by one machine/operator during the same period not to exceed 4 hours.
  - In each sample solid state relay, at least 15 wires shall be tested including one wire from each type of transistor, diode, capacitor, and resistor chips, three wires from each type of integrated circuit, and five wires connecting package leads, as applicable. If there are less than 15 wires in the solid state relay, all wires shall be tested. Sample solid state relays shall be inspected for lifted wires. Lifted wires shall be counted as nondestructive pull test failures.
  - c. The wire bonding lot shall be acceptable if no failure occurs. If one wire/bond fails another sample of two solid state relays shall be selected and one hundred percent nondestructively tested. If the second sample contains no failures the wire bonding lot is acceptable. If the second sample also contains failure(s), or more than one wire/bond fails in the first sample, the bonding machine/operator shall be removed from operation.
  - The failures shall be investigated and appropriate corrective action shall be implemented. The machine/operator shall be recertified in accordance with 30.3-1.6.1 before being returned to operation. All solid state relays bonded since the previous certification (lot sample bond strength test) shall be subjected to one hundred percent nondestructive bond strength testing.

## CONCLUDING MATERIAL

Custodians:

Army - ER Navy - EC

Air Force - 85

Review activities:

Army - MI Navy - OS

Air Force - 17, 99

NASA - NA

DLA - ES

User activities:

Army - AR, AT, ME Navy - AS, MC, SH Air Force - 19

Preparing activity:

Navy - EC

Agent DLA - ES

(Project 5945-0895)

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1. DOCUMENT NUMBER MIL-R-28750C 2. DOCUMENT DATE (YYMMOD) 16 February 1993

- 3. DOCUMENT TITLE
  RELAYS, SOLID STATE, GENERAL SPECIFICATION FOR
- 4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

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